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EFFECT OF PRE-OPERATIVE DIGITALIZATION IN REDUCING POST-OPERATIVE COMPLICATIONS 693
Samuel H. Geist, M.D. and Morris A. Goldberger, M.D., New York, N.Y.
CARDIORRHAPHY IN ACUTE INJURIES 696
William R. Smith, M.D. ..... Atlanta, Ga.
EMPYEMA OF THE PLEURAL CAVITY 711
George E. Heuer, M.D. ..... Cincinnati, Ohio
EXTERNAL DUODENAL FISTULÆ 725
Ralph Colp, M.D. ..... New York, N.Y.
EXTENSIVE RESECTION OF THE SMALL INTESTINE 745
Jacob Sarnoff, M.D. ..... Brooklyn, N.Y.
ALCOHOL, CIRRHOSIS AND LIPOMATOSIS 751
Sir John O'Conor, M.D. ..... Buenos Aires, Argentina
INTESTINAL OBSTRUCTION 755
Glover H. Copher, M.D. and Barney Brooks, M.D. ..... St. Louis, Mo.
MALIGNANT TUMORS OF THE TESTICLE IN CHILDREN 761
A. A. Kutzmann, M.D. and T. E. Gibson, M.D. ..... San Francisco, Cal.
ACUTE DEFERENTITIS AND FUNICULITIS 775
A. O. Wilensky, M.D. and S. S. Samuels, M.D. ..... New York, N.Y.
TRANSPUBIC REMOVAL OF THE PROSTATE FOR CARCINOMA 795
George Walker, M.D. ..... Baltimore, Md.
THE CONTROL OF HEMORRHAGE FOLLOWING PROSTATECTOMY 802
Harold L. Foss, M.D. ..... Danville, Pa.
ACETABULUM PERFORATED BY HEAD OF FEMUR 806
Samuel Kleinberg, M.D. ..... New York, N.Y.
SCLERODERMA WITH GANGRENE OF FINGERS 814
Harry Cohen, M.D. ..... New York, N.Y.
TREATMENT OF DISABILITIES OF THE HAND 816
Henry H. M. Lyle, M.D. ..... New York, N.Y.
GIANT CELL SARCOMA OF THE FEMUR 846
W. G. Turner, M.D. and Theo. R. Waugh, M.D. ..... Montreal, Canada
INDEX 853

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ANNALS of SURGERY

VOL. LXXVIII DECEMBER, 1923 No. 6

EFFECT OF PRE-OPERATIVE DIGITALIZATION IN REDUCING POST-OPERATIVE COMPLICATIONS*

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POST-OPERATIVE complications, especially those involving the respiratory tract, have always been a source of anxiety to the surgeon, and because of this fact we have been utilizing a procedure to minimize these conditions; a method that was described by one of us in association with Doctor Somberg last year.†

We classified the post-operative complications under the groups of vascular and non-vascular, and we were convinced that the pulmonary complications to a large extent were dependent on the vascular variations. The so-called hypostatic pneumonia we felt was due to a circulatory stasis in the lungs with poor aeration, upon which was superimposed an infection. Pulmonary œdema, another well recognized post-operative complication, is definitely of circulatory origin.

Miller and Polak have shown that there is a definite post-operative drop in blood pressure, the average being 14.2 mm. The return to normal usually takes twenty-four hours. It is this fall in blood pressure that results in a stasis in the smaller arterial and venous radicles. Studies carried out with the micro-capillary tonometer in observing the capillary changes immediately post-operative might add much to our knowledge of the circulation during these important first twenty-four hours. It is in all probability this first twenty-four hours that determines to a great extent the pneumonia or other vascular complications. We feel that probably all post-operative pneumonitis excepting those cases that are distinctly aspiratory have an etiology similar to the so-called hypostatic pneumonias. Other vascular lesions, such as embolism and thrombosis, are occasional post-operative complications, but just how much they are influenced by a maintenance of the post-operative pressure can only be judged after a very large series, as the incidence of their occurrence is very small.

Phlebitis may be due to operative trauma upon which is superimposed an infection; but here, too, stasis may play a rôle, and from that point of view, it too may react favorably to an improvement in the cardio-vascular activity.

* From the Gynecological Service (Doctor Brettauer), Mt. Sinai Hospital, N. Y. C.

† Geist and Somberg: Amer. Jour. Obstet. and Gynec., vol. iv, No. 2, August, 1922.

In post-operative shock we know there is a marked fall in pressure, and it seems rational to suppose if the pressure level can be maintained, a large group of patients may be spared this complication or at least that it may be distinctly lessened in gravity.

It was with these theoretical considerations in view that it was determined to try the value of some drug that would be a cardiac stimulant and would help maintain the blood and pulse pressure levels.

Digitalis was selected. To determine the action of the digitalis on these apparently normal hearts two methods were used, the study of the electrocardiographic tracing and the pulse and blood pressure. We found that we could get complete digitalization without any untoward effect on the patient and that the pulse rate in normal hearts was uninfluenced. The pressure was taken pre-operatively and six, twelve and twenty-four hours after operation. The average drop was found to be only 3 mm. within the first twelve hours, after which the tension gradually returned to normal.

At the time of the publication of the original paper we used two methods, the *slow* and the *rapid method*. We have found that the slow method had certain advantages, namely, ease of administration and absence of the digitalis nausea and vomiting, and for these reasons, of the 100 cases in the second series, all but eight were digitalized by the slow method. In the slow method digitan tablets, each 1½ grains, were used instead of the standardized tincture of digitalis. We give one tablet of digitan per fifteen pounds of body weight as the total amount. The first dose is given twenty-four hours before operation and then every two hours until the entire amount is taken. On the morning of operation two more such doses at two hour intervals are given and occasionally twelve hours post operative or twenty-four hours post-operative another dose can be administered. Digitan is standardized by its manufacturers, 1½ grains being equal to 1.5 c.c. of the standardized tincture. The digitalization effects last ten to fourteen days, so that if operation is deferred a few days, patients should not be redigitalized, as in such instances one may get nausea and vomiting or other distressing symptoms of poisoning.

TABLE I

Complete hysterectomy	9
Supravaginal hysterectomy & bilateral salpingo-oöphorectomy.	40
Plastics	14
Plastics with ligation of tubes and ventro-fixation	5
Removal of adnexa, ectopics, cysts, hydro-salpinges	15
Vaginal hysterectomy	6
Myomectomies with appendectomy or Alexander operation or ventro-suspension	6
Alexander operation	1
Exploratory laparotomy	2
Curettage and Dudley	1
Nephrectomy and ureterectomy	1
	100

In comparing the results obtained in our first series of cases we found, aside from the improved subjective symptoms and the general better impression of the post-operative convalescence, that the pulmonary complications had been definitely lessened from 15 per cent. in the nondigitalized cases to 0 per cent. in the digitalized.

We have carried on the work in an additional 100 major gynecological operations picked at random with a tendency to relegate to the digitalization group the poorer risks. Table I comprises the list of cases digitalized.

In this group of cases there were three that developed complications referable to the circulatory stasis. The histories are briefly abstracted below:

CASE I.—R. C. Supravaginal hysterectomy and appendectomy. Operating time, thirty-four minutes. Gas and ether anæsthesia. Six days post-operative developed fever which rose to 103.6° and on the tenth day dropped by crisis. The medical consultant found at the right base an area of consolidation about the size of a twenty-five cent piece. Over this area were a few subcrepitant râles and broncho-vesicular breathing. In the pelvis, however, was felt a massive exudate in both broad ligaments fixing the cervix. The question arises how much the minute lesion in the lung contributed to the condition. However, it is classed as a case of post-operative broncho-pneumonia.

CASE II.—L. P. Supravaginal hysterectomy and bilateral salpingo-oöphorectomy and appendectomy. Operating time, one hour. Gas and ether anæsthesia. During the operation the patient vomited and aspirated some of the vomitus. The next day patient developed a cough and had dullness over the right lower lobe, bronchial breathing, moist râles and purulent sputum. Diagnosis:—broncho-pneumonia, confirmed by the medical consultant.

CASE III.—Y. C. Pan-hysterectomy and bilateral salpingo-oöphorectomy. Operating time, one hour, five minutes. Gas and ether anæsthesia. On nineteenth day post-operative temperature rose to 102. Patient complained of pain in left thigh. There were no objective findings but a tentative diagnosis of phlebitis was made. Temperature dropped to normal next day and patient was discharged well on the twenty-fourth day post-operative.

In reviewing these cases we find in a series of 100, 3 per cent. complications, a very decided improvement over the reported percentage by various men, ranging from 8 per cent. to 27 per cent. in non-digitalized cases.

The 2 per cent. of post-operative pneumonia is open to question. The first case with the massive pelvic exudate is decidedly a case that admits of some discussion. The second case seems to be one of aspiration pneumonia, and no method of vascular stimulation can prevent such a calamity.

The third case of phlebitis was not proved, but we felt it fair, in view of the fact that the diagnosis was made, to include it in our record. There was no mortality in these 100 cases.

Comparing our results in this series with any random group of non-digitalized cases we feel that it confirms all the advantages previously claimed. It would seem, therefore, that it would be a decided advance to use this method as a routine for operative preparation just as much as the shave, tub, enema and morphine. The method is simple of execution, accurate in dosage and non-toxic in its effect if the directions are followed.

CARDIORRHAPHY IN ACUTE INJURIES

WITH REPORT OF TWO CASES AND A TABLE OF REPORTED CASES

By William Randolph Smith, M.D.

of Atlanta, Ga.

DEPARTMENT OF SURGERY EMORY UNIVERSITY MEDICAL SCHOOL

There is still a deal of romance connected with surgery of the heart, not only in the minds of the laity, but among the medical profession as well. When we realize that cardiac surgery has been considered possible only during the past twenty-seven years, and that during that time only a comparatively few cases of cardiorrhaphy have been attempted, it is easy to appreciate why such occurrences are of interest. The necessarily high mortality in heart wounds has led to a general belief among the laity that this type of injury is always fatal.

Case I.—I chanced to be in the emergency clinic at 11.30 P.M., February 12, 1923, when a colored boy, twenty-two years old, was brought in by the ambulance. According to some of his friends who came with him, he had been stabbed with a pocket knife during an altercation. The stabbing had occurred approximately 15 minutes prior to his arrival at the hospital. His clothing was soaked with fresh blood, but the only wound he showed externally was a vertical stab wound ½ inch long, in the third left intercostal space, 3 inches from the mid-sternal line. There was no outward bleeding from the wound at the time I saw him. The boy was unconscious, and somewhat cyanotic; his extremities were cold; his pulse was not perceptable at the wrists; his heart sounds were just discernable with the stethescope, as a faint, distant rumble. His respirations were slow and very shallow and every gasp seemed to be his last. A provisional diagnosis of stab wound of the heart was made, and the patient immediately transferred to the operating room. It took nearly 30 minutes to set up an operating room, during which time the anterior chest wall was cleaned off and painted with 3 per cent. iodine. Operation was started under novocain anæsthesia, approximately 45 minutes after receipt of the injury. A 5 inch incision was made over the fourth left rib and about 3 inches of this rib and costal cartilage were resected sub-periosteally. The pleura was then opened along the line of the skin incision. No effort was made to stay outside of the pleural cavity, for this had been opened by the original injury, and a hæmopneumothorax already existed. In order to get a slightly better exposure, a vertical incision was made downward from the original incision for a distance of about 2 inches. (See Fig. 1.) This gave a very good view of the distended pericardium which showed a vertical slit nearly ¾ of an inch long in its anterior surface, partly plugged with blood clot. From this partially occluded opening, trickled a steady stream of blood. The heart seemed practically motionless. The edges of this incision in the pericardium were grasped in Allis clamps, and the wound explored with a gloved finger. A wound in the heart wall could be felt. This procedure liberated the occluding clot, and resulted in a gush of blood through the pericardial wound. Simultaneously with this, the patient's general condition improved considerably and he began to show signs of returning consciousness, and his respirations improved. Ether, by the drop method, was then administered. During induction of the anæsthesia,

the wound in the heart was plugged with a gloved finger of the left hand. The pericardium was then opened widely in the vertical direction, and the apex of the heart grasped in an Allis clamp. By this means, the heart could readily be lifted up to the opening in the chest wall. Traction on the heart resulted in throwing the whole organ into fibrillation, from which it readily recovered a normal rhythm with the release of the pull. The wound in the heart proved to be nearly ¾ of an inch long and was situated in the upper portion of the right ventricle, close to the conus arteriosus. With the heart held in this way, it was a very simple matter to suture the wound. This was done with a continuous suture of chromic catgut on a curved intestinal needle, making 5 insertions. This suture controlled the hemorrhage completely. The sutures were placed through the entire thickness of the ventricular wall; which at this point is not very great. The posterior surface of the heart was rapidly explored and found to be uninjured. The pericardium was then sutured with a continuous suture of chromicized gut, leaving a small aperture at the lower angle of the wound in case of slight oozing. Following this, the lung was inspected, but no injury to this viscus was found. The blood that had accumulated in the pleural cavity was hastily removed, and the chest wall closed in layers, without drainage.

FIG. 1.—Photograph taken during the fourth week post-operative. To illustrate type of incision used.

Clinical Course.—The patient was sent to the ward with a pulse of 130 beats per minute, regular and of a fairly good volume. During the operation, he had received 1000 cubic centimetres of normal saline, subcutaneously. Although he was in considerable shock, he was placed flat in bed. It was deemed inadvisable to elevate the foot of the bed because of the added strain which that position might place upon the right heart. He was given a retention enema of a pint of hot tap water as soon as placed in bed, and this was repeated in 30 minutes. Thereafter he received eight ounces of water in this way every 4 hours for the first 24 hours. All of this he retained and absorbed readily, and at no time did he suffer from thirst.

During the next two days, a number of his friends were matched as prospective donors for transfusion. His condition seemed very favorable, so it was deemed advisable to delay transfusion until reports on the donors' Wassermann tests were received. On his third day post-operative, he was given 300 cubic

centimetres of whole blood by the Lindeman method. This procedure was repeated on the fourteenth day after operation, at which time 500 cubic centimeters of blood was introduced. He had no demonstrable, unfavorable reaction following either transfusion; his general condition seemed improved, and he said that he felt much better.

His temperature and pulse remained elevated during the first 16 days, the temperature staying between 99 and 102 degrees Farenheit, and the pulse between 115 and 130 beats per minute. Thereafter the temperature and pulse gradually descended so that by the end of the third week he had a normal temperature, and a regular, moderately strong pulse of 90 beats per minute.

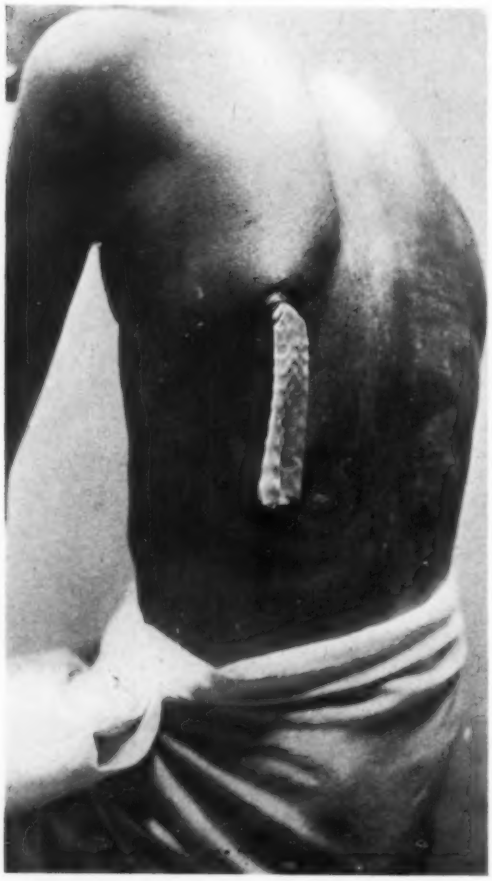

FIG. 2.—Photograph showing the valve tube drain in place in chest wall.

Examination of his chest during this period revealed the signs of a hæmopneumothorax on the left, and what would naturally be expected, a fairly well marked pericardial friction rub. The heart was displaced to the right. Small amounts of blood were aspirated from the left chest several times, but as the signs did not show much tendency to clear up spontaneously, I decided at the end of the fourth week, to drain the left pleural sac. A valve tube drain was inserted in the posterior axillary line between the seventh and eighth ribs. This type of drainage tube (see Fig. 2) was first suggested, as nearly as I can learn, by Tuffier, and I have found it very useful in a number of cases where a hæmopneumothorax existed. Air and fluid can readily be expelled through the tube from the chest, but nothing can get back, for as soon as even the slightest suction is applied at the chest end, the thin walls of the condum fall together and occlude the opening of the tube. In this way the fluid is removed and the lung expanded. X-ray examinations at intervals during convalescence showed a gradual improvement in his chest condition. The heart returned eventually, to the left side of the thorax.

During the fifth week of his illness the pericardial friction rub became less distinct. By the end of the sixth week, it was almost impossible to detect any abnormality in his cardiac sounds. The patient was allowed out of bed after his third week and since that time he has been up and about every day.

Other features in his progress which are of interest will be mentioned briefly. A few hours after operation, the patient's blood-pressure was 100 systolic and 60

diastolic. The pulse rate was regular, but the volume was irregular. Within 36 hours, the blood-pressure had risen to 120 systolic and 80 diastolic and has remained practically the same ever since. The irregularity in the force of the beats persisted for nearly ten days, gradually becoming less noticeable. A blood count on his second day post-operative showed a red cell count of 2,500,000 cells per cubic millimeter, a white cell count of 14,800 with 85 per cent. polymorphonuclear leucocytes, and a hæmoglobin of 60 per cent. On the day following his first transfusion, his red cells numbered 3,125,000, his white cells 20,000, with 90 per cent. polymorphonuclears, and his hæmoglobin measured 55 per cent. From then on the count, which was repeated every few days, remained much the same. There was a tendency toward a slow, gradual increase in the red blood cells and hæmoglobin, with a proportionate decrease in the white blood cells and in the proportion of polymorphonuclear cells. His urine showed a faint trace of albumen and some pus, as a result of a subsiding urethritis which he had at the time he was injured. This, however, cleared up during his enforced rest in bed.

Case II.—On the evening of June 18, 1923, a colored girl twenty years old, was brought to the clinic with a history of having been stabbed with a long bladed knife. What little clothing she had on was soaked with blood and she was bleeding profusely from a stab wound in the popliteal space of the left leg. In addition to this wound she presented three stab wounds of the left thigh and one stab wound of the left chest, none of which showed outward bleeding at the time she arrived at the hospital. This last wound was in the left breast about one inch above and one inch to the left of the nipple. Further examination revealed a broken fourth rib, and a hydropneumothorax on the left. The heart sounds were very feeble and distant, and slightly irregular. The patient was semi-conscious, pulseless, and gasping for breath. Her mucous membranes were ashy-pale, and she seemed practically exsanguinated. The wound in the popliteal space was hastily packed, to check the hemorrhage and the patient transferred directly to the operating room, with a tentative diagnosis of stab wound of the heart.

Operation was started as soon as possible under light ether anæsthesia. A semi-circular skin incision was made beneath the left breast and this structure was separated from the chest wall and retracted upward. Thus was exposed a fracture of the fourth rib about two inches from the sternum. The costal cartilages of the third and fifth ribs were cut through and intercostal incisions were made in the third and fifth spaces. The flap thus produced was opened outward by fracturing these three ribs. This movement exposed an incision in the pericardium about one inch long, which was immediately opened freely in the verticle direction, revealing a penetrating wound in the upper portion of the right ventricle about one inch long. The heart was beating very feebly and bleeding had practically ceased. During this time an assistant was attempting to introduce saline into an arm vein and adrenalin was introduced into the heart and heart muscle. Despite these measures the heart soon ceased beating entirely Artificial respiration, direct massage of the heart, and the introduction of saline directly into the left ventricle all were tried but without avail.

Post-mortem examination revealed that in addition to the heart wound, the popliteal vein had been severed and that there was a through and through wound in the anterior portion of the left lung.

History.—For many years cardiac surgery was regarded as impossible. In fact one of the master surgeons of his day uttered the dictum, but a little more than a quarter of a century ago, " Let no man who hopes to retain the respect of his medical brethren dare to operate on the human heart." (Quoted from.[1]) How odd that sounds today! Sherman [2] sums up the early history of heart

surgery in the terse statement, "The road to the heart is only 2 or 3 centimetres in length in a direct line, but it has taken surgery nearly 2400 years to travel it." Several factors were instrumental in finally opening up this field to the surgeon. First were the observations of several men, notably Paré and George Fisher, that heart wounds were not always fatal. Then in 1881, Roberts advised the suture of heart wounds. In 1895, several successful experiments in surgery on dog hearts were published. In 1896, Farina (Rome), performed the first cardiorrhaphy. The patient had been stabbed into the right ventricle. The wound was sutured with three silk sutures, and although the patient died of pneumonia on the sixth day, the feasibility of the procedure had been demonstrated and the way opened for the future. During this same year two other cases were attempted, by different surgeons, one of which recovered. To Rehn belongs the credit for the first successful cardiorrhaphy, published by him in 1897. From that year, to the present, the number reported has increased rapidly.

Physiology.—A great deal has been written on the physiology and the physio-pathology of the wounded heart. In this article I shall not attempt to summarize the information gained experimentally on animals and through observations on the human heart. I will mention one or two outstanding points, however, which appears to be of especial interest in connection with the human heart.

1. The human heart is quite tolerant of manipulations and traumatic insults. This has been amply shown by the manipulations to which this organ has been subjected by many surgeons in performing cardiorrhaphy. The heart will stand tugging, pulling, and compression sufficient to cut off all blood from flowing through its chambers, thus arresting circulation completely for a few seconds, and then resume a normal rhythm. The remarkable tolerance of the heart to injury, and to surgical procedures has been well demonstrated in numerous recent post-bellum reports of non-fatal wounds caused by projectiles, which remained in the heart or pericardium for a period of days, or in some cases even years, before surgical intervention was attempted. This work forms an intensely interesting chapter of cardiac surgery. (For brief review of this work see Matas, Keen's Surgery, vol. vii, pp. 713-737.)

2. Irritation of the bundle of His, either directly or indirectly as by pulling on the heart to deliver it into a wound will throw the whole heart into fibrillary contractions from which it recovers rapidly if the irritation is of short duration, such as a few seconds up to even a minute.

3. In many penetrating wounds into the heart chambers, the opening through the pericardium soon becomes plugged or at least partially occluded by blood clots. There results progressive bleeding into a closed pericardial sac, which may be the means of saving life for a short time, but which, if continued, gives rise to the most frequent cause of death in heart injuries, *viz.*: "heart tamponade" or compression. This symptom is the clearest operative indication.

4. Regeneration of muscle in wounds.[3] In open wounds of heart muscle

there is no true regeneration. The gap is filled with cicatricial tissue which proceeds from the scanty stroma of the myocardium. Sutured wounds of the myocardium heal with very little connective tissue reaction.

5. *Pneumothorax.*—Acute surgical pneumothorax was at one time dreaded, and various cumbersome pieces of apparatus were devised to combat the effects of this condition. The introduction of the Meltzer-Auer principle of intratracheal insufflation, was doubtless a great advance. Chest work during the recent war, however, has shown that the production of a complete pneumothorax by a large pleural opening is not only practicable, but constitutes the method of election in intra-thoracic surgery. Le Fort makes the statement "Pneumothorax is remarkably well tolerated; there would appear to be no greater risk in opening the pleura than the peritoneum." Furthermore, hemorrhage is considerably decreased in heart wounds as well as pulmonary wounds with the chest wide open. How to deal with the pneumothorax after the operation is another question upon which experiences in the World War have thrown some light. I will deal with this phase of the subject under the heading, " Treatment."

6. *Coronaries.*—Despite the view that the coronaries are end arteries, ligature of these vessels has been done a number of times during cardiorrhaphy without apparent damage to the heart.

Symptomatology and Diagnosis.—The diagnosis of a wound of the heart is not always an easy matter. There are numerous cases on record where cardiac wounds, demonstrated at autopsy, were overlooked by competent surgeons and medical men, as well as cases where the diagnosis of a wound was made, where none existed. There is no pathognomonic sign by which this injury can be definitely diagnosed. Under certain circumstances, as when there is a large wound of the chest wall exposing the heart, or when the wound is large enough to admit an examining finger, the diagnosis is obvious. If the symptoms of heart tamponade are present, these, coupled with the history of the case and with the site and direction of the wound, make the diagnosis relatively certain. Borchardt,[4] however, claims that this syndrome is more often absent than present. External bleeding is often absent or very scant, or at least has ceased by the time the patient is first seen by the surgeon. This is due to the fact that the external thoracic wound and that of the pericardium, fail to come into apposition. In these cases the diagnosis rests upon the signs of internal hemorrhage, the symptoms of tamponade, the ausculatory signs of cardiac injury or intrapleural hemorrhage. The immediate effect of heart injury in about one-half the cases is unconsciousness, from which the patient may or may not rally shortly. " While it is always desirable and important to make as accurate a diagnosis of the seat of the heart injury as possible, the surgeon can afford to act without the absolute certainty of heart injury in the presence of urgent symptoms calling for an exploratory pericardiotomy. We believe that in the thorax, as in the abdomen, when there is doubt, exploratory operations are perfectly justifiable.[5] " While the physical

signs presented in various wounds of the heart are of some didactic interest, they can rarely be used to great advantage in the diagnosis of this condition.

Treatment.—The oldest treatment in these cases was to close the external wound and pack the patient in ice. Later, ice to the precordium, absolute rest, mental and physical, mild stimulation with alcoholics, and the free use of opiates, were used; to this was added venisection after the effects of heart compression were appreciated. Later still, heart compression was relieved by direct tapping of the pericardium. Last, came operative treatment. The operative treatment of cardiac wounds may be considered more conveniently under several headings.

1. *Preparation.*—A very serious complication that may arise following an apparently successful cardiorrhaphy, and one which has not infrequently caused an unsuccessful result, is infection, either within the pericardium, the pleura, or both. While this infection may in some cases be carried in by the force producing the injury, it is as a rule, more likely the result of neglected asepsis during a hastily arranged operation. The large mass of evidence seems to indicate that it is far wiser to delay operation the additional time necessary to provide proper aseptic conditions. Even under such an arrangement, infection may ensue, but the results in the long run, are infinitely better.

2. *Anæsthetic.*—Much has been written on different types of anæsthesia in these cases, and I have referred above to the use of differential pressure devices in this class of work. Suffice it to say here, however, that the concensus of opinion seems to be, that a light ether anæsthesia is the most satisfactory. Anæsthesia is often not necessary till the pericardium is opened, but from this point on general anæsthesia is a decided help in many ways. Local anæsthesia has been used successfully by several operators, but many have tried it and found it necessary to change to general anæsthesia during operation.

3. *Thoracotomy.*—A great variety of approaches to the heart have been advised from time to time. In a general way, these may all be divided into two main classes, *viz.:* transpleural and extrapleural. If we limit ourselves to acute stab and gunshot wounds of the heart as I have attempted to do in this paper, and take into consideration several factors in connection therewith, we can simplify the question as to the type of thoracotomy considerably. In the large majority of these cases there already exists a pleural injury with at least a partial pneumothorax. In a certain proportion of cases (Pool estimated 13 per cent.) there is coincident lung injury, which requires surgical attention. This makes it advisable in all cases to examine the lung for evidence of injury. Also, the patient is often in an extreme condition, and immediate relief is imperative. A transpleural thoracotomy is a quicker and far more simple procedure than one by the extrapleural route. In fact in the hands of the average surgeon, the extrapleural thoracotomy is not very practicable. So then, when we take into consideration also, the relative safety of surgical pneumothorax, we may reasonably come to the conclusion that in this type of work the transpleural thoracotomy is the method of choice, in the

vast majority of cases. A discussion of the various methods and modifications of this procedure here, would necessarily entail a useless repetition of much that has already been written. (For detailed descriptions of procedures see [5, 7, 8, 9, and 10] of bibliography.)

4. *Opening the Pericardium.*—The safest and most expeditious procedure is to open the pericardium freely in its long axis. This will allow ample exposure of the heart, and will facilitate the quick locating of the site of bleeding. If the pericardium has been greatly distended with blood and heart compression exists, opening of the pericardium will result in a general improvement of the patient's condition, and a markedly increased amount of bleeding. It may be necessary to check this by gently plugging the hole in the heart with a finger of the left hand, while a suture is being placed.

5. *Cardiorrhaphy.*—The advisability of suturing heart wounds is no longer a question of discussion. The only points on which there is any difference of opinion are in regard to details of this procedure. Some prefer to grasp the heart near the base, compressing the cavæ, others prefer to grasp it near the apex with the hand, and still others prefer the use of a suture or instrument to hold the tumultous organ. In my case, I found that a very satisfactory grip could be obtained by using an Allis clamp near the apex. This was sufficient to hold the heart satisfactorily while the sutures were placed and also permitted me to lift the organ and inspect its posterior surface. When no traction was exerted on this clamp the heart action appeared perfectly normal. Most of the early operators used silk for suture material. For a time catgut was advocated and there seemed to be a trend in that direction. Several experimenters have reported that with silk they get a firmer and more resistant cicatrix. (Goebell, also [3]) F. T. Stewart,[11] however, expresses a preference for catgut, and cites one of his cases sutured with silk, in which the silk suture eventually sloughed through a sinus that developed. There are arguments for and against either continuous or interrupted sutures. At the present time there seems to be no unanimity of opinion on this point. Cases vary of course, but as a general rule, continuous sutures seem to be preferable. They are placed more quickly, and present fewer knots on the surface of the heart. Practically every operator has closed the pericardium with a continuous catgut suture.

6. *Drainage.*—There has been a good deal of discussion on the advisability of drainage in these cases, either of pericardium, pleura, or both; and it is very hard to draw any conclusions from the evidence presented. There has been a large amount of work done in recent years, both during and following the war, on foreign body extractions from the heart and pericardium. These cases unless definitely septic have been, as a rule, closed tight, either with or without the aspiration of the air from the pleural cavity. Should I ever have occasion to perform another cardiorrhaphy, I shall modify the procedure that I used in the case reported in this paper to this extent: I will close the pericardium without drainage, leaving a small opening near the apex and will, as part of the operation, insert through the chest wall in a dependent position in the posterior axillary line, a valve drain, such as I have subsequently used

TABLE I.

Table of Wounds of Right Ventricle.

Surgeon	Year	Patient	Type of wound	Time before operation	Anæsthetic	Type thoracotomy	Suture material	Drainage		Complications	Result
								pericardium	pleura		
1. Bradbury [14]	1909	♀44	Stab	1 hour	E	O. F. 3-4	Linen	O	Yes	O	Recovery.
2. F. T. Stewart [15]	1909	♂21	Stab	Soon		O. F. 3-4	Catgut				Died in 1 hour.
3. Djanelidze [16]	1911	♂20	Stab	2 hours	E	O. F. 3-4-5	Silk	O	O	O	Recovery.
4. Krasnopolskii [17]	1911	♂27	Stab	1½ hours	None	O. F. 2-3-4	Silk	O	O	Alcoholic delirium	Died in 30 hours.
5. Nassau [18]	1913	19	Stab	Soon	E	O. F. 3-4	Silk	For 48 hrs.	4 days	Empyema drained 11 days later	Recovery.
6. De Verteuil [19]	1913	♂15	Stab	Soon	E	O. F.					Died on table.
7. Rothfuchs [20]	1916	♂	Stab	1½ hours			Sutured	O	O	Broncho-pneumonia	Died second day.
8. Ertaud [21]	1916	♂20	Shell fragment	Soon		O. F.	Catgut	O	O	Several other wounds also	Died in 9 hours.
9. Rhodes [22]	1917	♂30	Stab	Soon						Attempt to suture unsuccessful due to position of wound	Died in ½ hour.
10. Adenot and Proby	1919	♂	Stab	3 hours			Sutured			Hemorrhage from wound in lung	Died in 12 hours.
11. Burian [23]	1919	♀11	Needle puncture	4 hours		Severed costal cartillages	None used	O	O		Recovery.
12. Pratt [24]		♂19	Stab	1½ hours		O. F. 3-4-5	Catgut	O	O	Pneumonia	Recovery
13. Vidal [25]	1922	♂34	Stab	½ hour		Mid-sternal thoracotomy	Catgut	O	O	O	Recovery.
14. W. R. Smith [26]	1923	♂22	Stab	½ hour	E	Resection 4	Catgut	O	O	Empyema	Recovery.
15. W. R. Smith [26]	1923	♀20	Stab	1 hour	E	O. F. 3-4-5	Catgut			Other wounds including severed popliteal vein	Died on table.

Note: E, Ether, open cone.
O. F., Osteoplastic flap, numbers indicate ribs.
O, None.
Where reporters did not specify details blank spaces have been left.
B., Billroth's A. C. E. mixture.
G. S., Gun shot wound.
C-M., Chloroform, ether, alcohol mixture.

TABLE II.

Table of Wounds of Left Ventricle.

Surgeon	Year	Patient	Type of wound	Time before operation	Anæsthetic	Type thoracotomy	Suture material	Drainage		Complications	Result
								pericardium	pleura		
1. F. T. Stewart [37]	1909	♂36	Stab	1 hour	E	O. F. 3-4	Silk	O	Yes		Recovery.
2. Martinez and Capas [38]	1910	♂25	Stab	3 hours	Chlor.	O. F. 3-4-5	Sutured	Yes	O	Shock and hemorrhage	Died in 30 hours.
3. Von Hacker [39]	1910	♂36	Stab	24 hours	B	Resection 4-5	Sutured				Died on table.
4. F. T. Stewart [40]	1910	♂23	Stab	1½ hours		O. F. 4-5	Catgut	O	Yes		Died in 41 hours.
5. Billings [41]	1911	♂31	Stab	Soon	E	O. F. 4-5	Catgut	O	O	Cardiac failure	Died in 48 hours.
6. Schafer [32]	1912	♂37	Stab	Soon	E	Resection 4	Catgut	O	O	O	Recovery.
7. Mitchel [33]	1912	♂59	Stab	1½ hours		Sixth rib sectioned	Linen	For 18 days	O	Alcoholic delirium	Recovery.
8. Lucas	1913		Stab				Sutured	Yes			Recovery.
9. Danna [34]	1913	♂30	Stab	Soon	Local	O. F. 3-4-5	Catgut	O	O	Broncho-pneumonia	Recovery.
10. DeVerteuil [35]	1913	♂14	Stab	2 hours	E	O. F.	Silk	O	O	Radial and renal emboli	Recovery.
11. Schafer [36]	1914	♂16	G. S.	Soon	E	Resection 4	Catgut	O	O	Lung abscess later	Recovery.
12. W. J. Coleman [37]	1914	♀36	Razor cut	Soon	E	Resection 5	Catgut	Yes	Yes		Recovery.
13. M. Prat [38]	1914	♂30	G. S.	24 hours	Chlor.	O. F.	Catgut	Yes	Yes		Died.
14. Frist [39]	1915	20	Stab.	6 hours		O. F. 5-6	Sutured				Died.
15. Leveuf [40]	1915	♂19	G. S.	1 hour		Resection 4-5	Catgut	O	O	O	Recovery.
16. J. F. Jones [41]	1916	18	Stab	½ hour		O. F. 3-4-5	Silk	For 4 days	For 13 days		Recovery.
17. F. C. Pybus [42]	1917	♂25	Stab	2 hours	E	O. F. 5-6	Catgut	O	O	Several other wounds, pericarditis	Died 5 days.
18. Constantini and Vigot [43]	1917	♂	G. S.	Few hours	E	Resection 3-4-5	Sutured	O	O	O	Recovery.
19. Butler [44]	1918	♂	Stab	4½ hours	E	Resection 5	Catgut	O	O		Recovery.
20. Warner [45]	1919	♂24	Stab	½ hour	E	O. F. 4	Catgut	Yes	Yes	Slight infection	Recovery.

TABLE II. (*Continued*)

Table of Wounds of Left Ventricle.

Surgeon	Year	Patient	Type of wound	Time before operation	Anæsthetic	Type thoracotomy	Suture material	Drainage		Complications	Result
								pericardium	pleura		
21. A. W. Collins [46]	1920	♂20	G. S.	2 days	E	O. F. 3-4-5	Catgut	O	Yes	Pneumonia-empyema, got up on 6th day	Died 11 days.
22. Cappette [47]	1921	♀17	G. S.	1 hour			Sutured	O	O	Pleural effusion	Recovery.
23. Monad [48]	1921	♀30	Stab	3 hours			Sutured	O	O	Pleural effusion	Recovery.
24. Hartman-Keppel [49]	1921	♂47	Rifle bullet	20 hours	Chlor.	Mid-sternal	Catgut	O	O	Thrombosis left axillary artery	Recovery.
25. Santy [50]	1922		G. S.			Intercostal	Catgut	O	O	Hæmothorax	Recovery.

TABLE III.

Table of Wounds of Right Auricle.

Surgeon	Year	Patient	Type of wound	Time before operation	Anæsthetic	Type thoracotomy	Suture material	Drainage		Complications	Result
								pericardium	pleura		
1. F. T. Stewart [51]	1910	♂26	Stab	2 hours		O. F. 3-4	Catgut				Recovery.
2. Noland [52]	1912	♂22	Stab	Soon	E	O. F. 3-4-5	None used			Left hydro-thorax	Recovery.
3. Fraser [53]	1917	♂	Shell fragment	Soon		Resection 6	Sutured	Yes	Yes	Other wounds	Recovery.
4. Moure and Saupault [54]	1921		Stab	½ hour		Mid-sternal	Catgut				Recovery.
5. Miginiac [55]	1922	♀24	Stab	1½ hours		Mid-sternal	Catgut	O	O	3 months pregnancy. Right hæmothorax	Recovery.

TABLE IV.

Table of Wounds of Left Auricle.

Surgeon	Year	Patient	Type of wound	Time before operation	Anæsthetic	Type thoracotomy	Suture material	Drainage		Complications	Result
								pericardium	pleura		
1. Long [56]	1914	♂32	Stab	¾ hour	E	O. F. 3-4-5	Catgut	O	Yes	Effusion-pericardial and both pleuræ	Recovery.
2. Constantini and Vigot [57]	1917	♂	G. S.	4 hours	E	O. F. 3-4-5	Sutured	O	O	Left empyema	Recovery.
3. Black [58]	1920	♂15	Stab	3 hours	E	O. F.	Catgut	Yes	O	Probable pulmonary embolus	Died in 4½ hours.
4. Harvey [59]	1921	♂	Ice pick	Soon	E	O. F.	Catgut	O	O	Wound on posterior surface overlooked	Died in few hours.
5. Miginiac [60]	1922		Stab				Sutured				Recovery.

TABLE V.

Table of Miscellaneous Cases.

Surgeon	Year	Patient	Type of wound	Position of wound	Time before operation	Anæsthetic	Type thoracotomy	Suture material	Drainage		Complications	Result
									pericardium	pleura		
1. Lucas	1913		G. S.	R. and L. Vent.				Sutured	Yes			Recovery.
2. E. M. Freese [61]	1920	♂	Stab	R. and L. Vent.	½ hour	E	O. F. 4-5	Sutured	O	O	Bronchitis	Recovery.
3. Quenu [62]	1920	♂	G. S.	R. and L. Vent.	11 hours	C-M	O. F. 3-4-5-6	Catgut				Died on table.
4. Mocquot and Constantini [63]	1919	♂19	Shell fragment	Anterior coronary artery	6 days	E	O. F.	Sutured	O	O	Pleural effusion	Recovery.
5. Burian [64]	1919	♂26	Stab	Anterior coronary artery	2 hours		O. F. 3-4-5	Catgut	O	O	Pleural effusion	Recovery.
6. Mauro [65]	1919	♂	Hand grenade	Heart wall	1 hour		Resection 5-6	None	O	Yes	Other wounds also	Recovery.
7. Lott [66]	1911	♂	Stab	Heart wall	Soon		Resection 4	None	Yes	Yes	Gangrene of lung	Recovery.
8. Crabtree [67]	1918	♂	Rifle bullet	Heart wall	4 days		Resection 4-5	None	Yes	Yes		Recovery.

in this case. (See page 698.) In this way, I feel confident that excess accumulations of fluid in the pericardium or pleura will be obviated, the pneumothorax will be rapidly overcome, and drainage against potential infection will be instituted. If infection does not supervene, this tube will soon be walled off by adhesions on the pleural surface and can be removed in ten or twelve days.

Post-operative Treatment.—The post-operative treatment of these cases is naturally directed against shock and hemorrhage. Crile's suggestion about using the Fowler position to relieve strain on the heart, should be followed, rather than placing the head low. Fluids should be administered in the form of saline under the skin and hot coffee per rectum. I prefer not to introduce saline directly into the circulation for the reason that there is no danger of causing an acute cardiac dilatation in these patients. Fluid introduced beneath the skin is taken up by the circulation with surprising rapidity and is probably borne better. Several donors should be matched for transfusion as early as possible, so that in the event of necessity, this procedure may be used. Whole blood transfusions, because of the less frequent, and less severe reactions, are by far the more desirable. The use of digitalis bodies, morphia, strychnia, etc., as well as fluids by rectum, are details of treatment which do not require special mention here.

Statistics.—Statistical studies of cardiorrhaphy have been published from time to time both in this country and abroad. The earlier statistics showed a mortality of 56 to 65 per cent. More recent statistics give a lower mortality. The later statistics, however, may not be as complete as those published earlier, for while today, practically all successful cases get into the literature, undoubtedly many cases terminating fatally are never published. In the earlier days of cardiorrhaphy this was probably not so true. While it is difficult to draw conclusions from published statistics of this kind, we may with reasonable assurance accept certain statements, made as early as 1906 [12] as being true today. That is in a general way, cases of heart wounds have 3 chances in 4 of surviving long enough to permit surgical intervention; 1 chance in 10 of healing spontaneously, and about 1 chance in 2 of being cured by surgery. The place where we must improve in connection with this branch of work is in diagnosis. The treatment today is fairly well understood and carried out. If all cases of penetrating heart wounds could be collected, including non-operated cases, the chances are that the mortality rate from such injuries would be higher than we now believe it to be. In my very limited experience, I have seen two cases in which at autopsy unsuspected penetrating wounds of the heart were found. Undoubtedly many cases go unrecognized.

In 1909, Peck [13] published a table of the reported cases. He found 161 operated cases with a mortality of 63 per cent. In 1912, Pool [6] amended the list to bring it up to date. He added 79 cases with a mortality of 47 per cent. In the appended tables, I have attempted to collect those cases not included in the above lists, in an effort to bring the figures on cardiorrhaphy up to date. My list contains 58 cases, with a mortality of 33 per cent.

SUMMARY

1. Cardiorrhaphy is a comparatively recent advance in surgery.

2. The human heart is very tolerant of manipulation. This fact has been repeatedly demonstrated, especially in connection with foreign body extractions during and since the World War.

3. Surgical pneumothorax is remarkably well tolerated.

4. The symptomatology of heart injuries varies widely, and as a consequence the diagnosis of this condition is often very difficult. In cases of doubt, therefore, exploratory operations are justifiable.

5. Transpleural thoracotomy under general anæsthesia is probably the procedure best suited to the average case of this type.

6. Drainage in these cases can be accomplished best through the medium of a simple valve tube drain through the chest wall.

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EMPYEMA OF THE PLEURAL CAVITY*

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There are certain conditions which we must attempt to meet if we are to satisfactorily treat empyema of the pleural cavity. They are:

1. An early recognition of the disease, whether we intend immediate surgical treatment or not.

2. A low mortality.

3. The prevention of chronicity, *i.e.*, the development of chronic from acute empyema.

4. The shortest possible convalescence.

5. The restoration of the functional capacity of the lung of the involved side to as nearly a normal condition as possible.

6. The certain cure of chronic empyema should it develop; and with a low mortality.

How can we meet these conditions? Obviously one way of approach is by the study of a fairly large, carefully followed series made with the purpose of discovering the factors which have contributed toward or prevented their realization. We have made such a study of 455 cases of empyema, 425 of which occurred in the Johns Hopkins Hospital series and 30 in the Cincinnati General Hospital series the past year; and we shall consider the above conditions in the light of these studies.

1. *Early Recognition of Empyema.*—This from a surgical viewpoint is a difficult condition to meet, for the early diagnosis of empyema will remain in the majority of instances in the hands of the internist and general practitioner, and therefore largely out of our control. But we may as surgeons emphasize the importance of early diagnosis and early surgical consultation, for a study of our cases seems to show the evil effects of tardy recognition of the disease. That empyema has frequently been recognized late in the past and is still recognized late in many instances has been our experience. Of the 425 cases in the Johns Hopkins Hospital series 213 had symptoms of empyema for 1 to 4 weeks before entering the hospital, only 1 of which had been operated upon; 81 had symptoms of empyema for 1 to 3 months, only 4 of which had been operated upon; 40 had symptoms for 3 to 6 months, only 14 of which had been operated upon; and 21 had symptoms for 6 to 12 months, of which 11 had been operated upon. Fifty per cent. of the total series of cases therefore had been rather promptly recognized, while the other 50 per cent. had either not been promptly recognized or, if so, had not been promptly treated. The harmful effects of such tardy recognition of the disease cannot be dogmatically stated, for there are factors concerned which

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are difficult to interpret. Yet our studies show, I think, that tardy recognition and late treatment contribute (a) toward the development of serious complications, (b) to a higher mortality, and (c) to prolonged convalescence and chronicity. At the time of their admission to the hospital with empyema, 20 cases in our series had pulmonary abscesses or gangrene, 8 had septicæmia (confirmed by blood culture), 4 had general peritonitis, 3 had suppurative pericarditis, 3 had meningitis or endocarditis and 9 had bronchial fistula due to the rupture of the empyema into a bronchus. Forty-seven cases therefore (10 per cent. of the entire series) had very serious complications in addition to empyema, and our records show that three-fourths of the total mortality in the entire series occurred in the group of cases with the above complicating conditions. I will grant that it is difficult to say that in the above cases with serious complications the empyema was primary, the complicating conditions secondary; for such complications may be manifestations of a general infection of which empyema is one. But I feel sure that a certain proportion of these complicating conditions follow acute empyema if left untreated, a view which is abundantly supported by our experience with infected thoracic war-wounds in France. Not only then is the danger of serious complications and thereby the mortality increased by tardy recognition, but the convalescence in empyema is prolonged and the tendency toward chronicity increased. In the Johns Hopkins Hospital series, 67 patients were admitted with chronic empyema and draining sinuses the result of operations performed elsewhere; and 20 cases operated upon primarily at the Johns Hopkins Hospital became cases of chronic empyema. In the Cincinnati General Hospital series of 30 cases admitted in the past year 7 were cases of chronic empyema. Ninety-four cases therefore (exclusive of the cases of tuberculous empyema) in a series of 455, or 20.7 per cent., were on admission cases of chronic empyema or subsequently became cases of chronic empyema. When we review the histories of these cases we find that in the large majority, operation was performed late—after weeks or months of evident empyema. When we compare with these the period of convalescence and the percentage tendency to chronicity of acute cases promptly recognized and treated, we feel sure that delayed recognition and late treatment of empyema is one of the causes of prolonged convalescence and chronic empyema.

2. *A Low Mortality.*—In order to attain as low a mortality as possible in the treatment of empyema, we must know the factors which contribute to the mortality in this disease. They are many and varied; and, while practically several of them may, in a given case, be operative, we shall for the moment treat them separately.

(a) *Age.*—When we study the mortality of empyema according to age periods, we find that in infants under two years of age the mortality is 39 per cent., that it drops in children from 2 to 5 years to 16.4 per cent., and reaches its lowest level (1.6 per cent.) in children from 5 to 10 years of age. It rises from this period, being 11 per cent. in young adults from 11 to 20 years of age; 16 per cent. in adults from 21 to 30 years, 17 per

cent. from 31 to 40 years, and 34.8 per cent. from 41 to 50 years. From this second high peak it again drops to 7.7 per cent. in adults over 50 years of age. The highest mortality in empyema therefore according to our records occurs in infants under two years of age and in adults between 40 and 50 years of age; the lowest mortality occurs in children from 5 to 10 years of age.

(b) *Etiology of the Disease.*—Studied from the standpoint of etiology the mortality in post-pneumonic empyema was 10.9 per cent., in tuberculous empyema was 42.8 per cent., in post-operative empyema was 41 per cent., in post-traumatic empyema was 33 per cent. and in empyema due to a miscellaneous group of infections 40.5 per cent. Etiologically, therefore, the highest mortality occurs in the tuberculous empyema, the lowest in the post-pneumonic empyema.

(c) *Type of Infecting Organism.*—Studied from the standpoint of bacteriology the pneumococcus empyema showed a mortality of 9 per cent., the streptococcus pyogenes empyema of 22.5 per cent., the streptococcus hæmolyticus empyema of 15.5 per cent., the staphylococcus empyema of 17 per cent. and the influenza bacillus empyema of 16 per cent. In this series streptococcus pyogenes empyema shows the highest mortality; pneumococcus empyema the lowest mortality.

(d) *Presence of Complicating Conditions.*—As above noted by complicating conditions, I refer to acute or unresolved pneumonia, either unilateral or bilateral, pulmonary abscess, pericarditis, peritonitis, meningitis, septicæmia, etc. Studied from the standpoint of the presence or absence of complicating conditions at the time of admission for empyema, we find that the mortality of empyema when such complications are present is 48 to 50 per cent.; in the absence of such complications is 6.5 per cent.

(e) *The Duration of Symptoms before Operation.*—Studied from the standpoint of the duration of symptoms of empyema before operation was performed, the mortality in the 213 cases with symptoms of empyema of 1 to 4 weeks' duration was 20.6 per cent.; in the 81 patients with symptoms of 1 to 3 months' duration was 9.8 per cent.; in the 40 patients with symptoms of 3 to 6 months' duration was 10 per cent.; and in the 67 patients with symptoms of over 6 months' duration was 9 per cent. The comparatively low mortality in patients with symptoms of long duration is to be expected and has no bearing on my remarks concerning the value of early diagnosis and prompt surgical consultation; for the majority of patients who have survived the first four weeks of empyema are those who have escaped the serious complicating conditions to which I have just referred. But that they have not entirely escaped and that they have suffered from the lack of prompt treatment is indicated by a study of the autopsy records of those dying. Of the 28 deaths which occurred in those with symptoms of more than 1 month's duration 14, or 50 per cent., showed at autopsy some serious complicating condition such as lung abscess, pericarditis, septicæmia, meningitis and bronchopneumonia.

(f) *The Kind of Anæsthesia.*—It is indeed difficult in this series to form any certain estimate of the influence of the various forms of anæsthesia upon the mortality. Ether, chloroform, nitrous oxide-oxygen and local anæsthesia were all used. Naturally local anæsthesia was the anæsthetic of choice in the most dangerously ill patients and therefore judged purely from the standpoint of anæsthesia the mortality is highest in this series following operations under local anæsthesia. This we know is incorrect, for the deaths were not anæsthetic deaths but deaths due to serious complicating conditions. On the other hand, we have some evidence of the harmful effects of general anæsthesia. A careful analysis of the deaths in this series shows that 3 patients apparently free from the condition before operation developed an acute bronchopneumonia which was at least the immediate cause of death; one patient died upon the operating table from the aspiration of pus through a bronchial fistula—a death which might have been averted—and one patient died upon the operating table either from anæsthesia or pleural reflex or acute surgical pneumothorax, it is not clear which. We have evidence therefore that the kind of anæsthesia is a contributing factor in the mortality, although of slight importance as compared with the others we have enumerated; and that local anæsthesia is the safest and therefore the best whenever it can be used.

(g) *The Kind of Operation.*—For the present we shall speak only of the operations for acute empyema; leaving the subject of chronic empyema to be discussed later. They are commonly three in number, *i.e.*, aspiration drainage, meaning by that the establishment of continuous air-tight suction drainage without the production of pneumothorax; intercostal incision with drainage, and rib resection with drainage. A study of our cases shows that in a certain and relatively large group of cases, *i.e.*, those not seriously ill in which the empyema is localized in the sense that the visceral and parietal pleuræ have become adherent about the empyemic cavity, the kind of operation has little influence upon the mortality. On the other hand, the kind of operation performed becomes a factor of great importance in the mortality in two groups of cases—those which are dangerously, acutely ill with marked toxæmia; and those with unilateral or bilateral pneumonia. In both groups the least possible operation which will suffice alone is permissible; in the latter group especially surgical pneumothorax must be prevented. We have noted a striking improvement in our mortality rate, especially in children, since we have substituted aspiration drainage for rib resection; and due, we believe, to the lessening of the seriousness of the operation and to the prevention of surgical pneumothorax.

(h) *The Kind of Post-operative Treatment.*—It is obviously difficult to form any just estimate of the influence of the post-operative treatment upon the mortality. So many factors come into play, namely the age of the patient, the etiology of the disease, the presence of complicating conditions, etc. In the Johns Hopkins Hospital series the operation (rib resection and drainage) was practically a constant, the post-operative treatment a variable.

Among 221 cases with no special post-operative treatment the mortality was 20 per cent.; in 65 cases treated with boric acid, weak bichloride and other irrigations, the mortality was 9.2 per cent.; in 50 cases treated by the Carrel-Dakin method the mortality was 4 per cent. It is perfectly clear that these mortality rates cannot be attributed to the kind of post-operative treatment; for an analysis of the first group, for example (those without any special post-operative treatment; mortality 20 per cent.), shows that a fairly large percentage died within 24 to 48 hours after operation before any form of post-operative treatment could have had any marked influence upon the course of the disease. Yet when we survey our experience we feel sure that the kind of post-operative treatment does influence the mortality and by quickly overcoming the toxæmia, by promptly controlling the infection and therefore the development of serious complications and by shortening the convalescence and therefore avoiding chronicity. Undoubtedly in our own experience the post-operative treatment of empyema by the Carrel-Dakin method has contributed to our results.

These, then, are the factors which a study of our cases has shown contribute to the mortality in empyema, and to which we must direct our attention if we are to attain a low mortality in the treatment of the disease. Which of them are of prime importance, which of lesser importance may be gathered from a closer study of our deaths. When we study the *factor of age*, which has so large an influence upon the mortality, we find the following:

In infants under two years of age the mortality in the Johns Hopkins Hospital series, as previously noted, was 39 per cent. Of the 16 deaths which occurred, autopsies were obtained in 10; and in these death was not due to simple empyema but due to the serious complications which I have previously enumerated. In 6 cases autopsies were not obtained and the exact condition is not known. In children from 2 to 5 years of age there were 13 deaths (mortality 16.4 per cent.), 12 of which were due to serious complicating conditions, either in the lungs or elsewhere. In children from 5 to 10 years of age, there was 1 death (mortality 1.6 per cent.), and that due to pericarditis. It is clear that in the last group the low mortality was due to two factors, *i.e.*, to the fact that the empyemas were post-pneumonic and that the disease was not associated with serious complications. When we examine the deaths in the succeeding age groups we find again that they are due to serious complications associated with empyema and to the introduction of other factors, such as traumatic conditions, post-operative complications and tuberculosis. We see therefore that age is a factor in the mortality only insofar as it predisposes to or is associated with serious complicating conditions. In infants the mortality is high because of the serious nature of the pulmonary infection which precedes and accompanies empyema. Infants stand infection badly, they are prone to develop bilateral pneumonia, bilateral empyema, multiple pulmonary abscesses, septicæmia and the complications of systemic infection. In children from 5 to 10 years of age, the mortality is low because perhaps of the less serious nature of the

primary pulmonary infection and certainly because of the absence of serious complications. In adult life the mortality again rises, due in part to the complications which accompany the empyema but due in part also to the introduction of new factors which become operative in adult life, *i.e.*, traumata, surgical operations, unusual infections and tuberculosis. In the aged the mortality again drops because the empyemata are post-pneumonic and unassociated with serious complications.

Similarly, when we study *the factor of the kind of infecting organism*, we find that the mortality in pneumococcus empyema is low, because proportionally it is less frequently associated with serious complicating conditions; that the mortality in streptococcus and tuberculous empyema is high, due in part to the graver toxæmia but in greater part to the proportionally higher incidence of serious associated complicating conditions.

In the light of these studies it becomes evident that the factor which contributes in largest measure to the mortality in empyema is the presence of serious complicating conditions. In order to attain a low mortality in the disease we must aim to make an early diagnosis, to recognize by physical, X-ray and other examinations the presence of complicating conditions; and our treatment must be directed toward supporting the strength of the patient, toward avoiding all unnecessary trauma by operative measures, toward preserving the greatest possible function of the lungs by avoiding surgical pneumothorax, and toward lessening and controlling infection by appropriate post-operative measures.

3. *The Prevention of Chronicity.*—An examination of the reports from various hospitals shows but few accurate statements regarding the incidence of chronic empyema. Wilensky, reporting the cases of empyema at the Mt. Sinai Hospital between 1903–1915, found that 23 per cent. of the cases developed chronic empyema. Other statistics are not so clear, but it is evident that in any large series of cases the incidence of chronic empyema has in the past been relatively high. In the above series of 455 cases, 94, or 20 per cent., either were chronic on admission or were acute and became chronic following treatment. It was this fact which originally stimulated us to study empyema in the hope of reducing the incidence of chronic empyema.

We shall reserve for a subsequent paragraph some remarks upon the pathology of chronic empyema and confine our attention here to the factors which clinically seem to be responsible for the development of chronic empyema. A study of the cases admitted with chronic empyema and of those admitted with acute empyema, which subsequently became chronic, shows that the factors involved are (a) delayed operation—by that meaning the presence of empyema for weeks or months before drainage is instituted, (b) the failure to produce adequate drainage, (c) the failure to overcome the infection of the pleura, and (d) the failure of constant supervision in post-operative care until it has been proven by physical and X-ray examinations that the lung has completely expanded and the empyemic cavity has thereby been obliterated. All these factors when closely examined show the impor-

tance of infection in the causation of chronic empyema and the necessity of overcoming it in preventing chronicity. The constant finding in chronic empyema is thickened pleura, the parietal pleura being always much thicker than the visceral. It is caused by infection, for we have proven that so soon as the infection is removed the thickened pleura disappears. It is the cause of the failure of the lung to expand and the reason for the persistence of the cavity. Delayed operation by causing thickened pleura, inadequate drainage, the presence of pockets, and foreign bodies and the results of inadequate post-operative supervision are factors dependent upon infection. In the prevention of chronicity, therefore, we must direct our attention particularly toward overcoming or providing conditions so that nature may overcome the intrapleural infection. It may be accomplished in various ways. J. M. Flint and B. Douglas, working in the Yale Clinic at New Haven in a series of 102 cases of acute empyema which will be reported, have not had a single case of chronic empyema develop. Their procedure has been rib resection with constant suction tube drainage. They have not made use of irrigations nor the Carrel-Dakin method. We, using aspiration drainage or rib resection with air-tight suction drainage depending upon the condition of the patient and making use of the Carrel-Dakin method in the post-operative treatment, have had no case of chronic empyema develop from an acute empyema in the past four years. Other methods may be as adequate, providing they are employed reasonably early and ensure the prompt elimination of the intrapleural infection. The criteria for satisfactory progress in the post-operative course are the rapid disappearance of toxic symptoms; the rapid fall of the temperature to normal, the decrease in the amount of the discharge and the constant progressive diminution in the size of the intrapleural cavity as determined by periodic X-rays and actual measurements. No patient with acute empyema should in our opinion be discharged from the hospital until it has been proven that the lung has completely expanded and the cavity has been entirely obliterated; for only under these conditions may we be sure that the condition is cured.

4. *The Shortest Possible Convalescence.*—Our remarks upon this subject form a corollary to those we have made in the preceding paragraph. Prolonged convalescence is a manifestation of chronicity and therefore in attaining the shortest convalescence we must study the factors which contribute to chronicity. As previously noted they include (a) delayed operation, (b) inadequate drainage, (c) the failure to overcome the intrapleural infection, and (d) the failure of adequate post-operative treatment. The first three of these factors require no further discussion, the fourth—the failure of adequate, constant post-operative supervision—should perhaps be discussed more fully. In the Johns Hopkins Hospital series we have studied the late results from various viewpoints, one of which has been the period of convalescence following various forms of post-operative treatment. With an average hospitalization period of 36 days, 12.2 per cent. of the cases receiving *no special post-operative treatment* were discharged with their empyema cured, 67.8 per

cent. with draining sinuses; 10.7 per cent. of the cases treated after operation with *boric acid or other irrigations* were discharged cured, 80 per cent. with draining sinuses; and 45 per cent. of the cases treated after operation by *the Carrel-Dakin method* were discharged cured, 55 per cent. with draining sinuses. The great increase in the percentage of cures in a 36-day interval following the Carrel-Dakin treatment is a striking commentary upon the value of adequate post-operative treatment. Now when we follow the after-history of patients discharged from the hospital, we find that those discharged with their empyemic cavities obliterated and their sinuses healed remain well practically without exception. Of those discharged from the hospital with cavities unobliterated and with draining sinuses, 80 per cent. eventually heal and get well while 11 per cent. fail to heal. Thus a fairly large proportion of cases do get well, but when we study the period of convalescence of those discharged from the hospital with draining sinuses, we find that over 75 per cent. require over three months for healing and many six months or a year; while as above noted 11 per cent. entirely fail to heal. These findings indicate that the shortest possible convalescence can be obtained only by continuous hospital treatment; and if this treatment is adequate our records and those of Flint and Douglas show that the large proportion of cases of acute empyema can be cured in 40 days, by cured meaning the obliteration of the cavity and the healing of the sinuses. So important has this matter seemed to us that we have in the past three or four years, in cases under our personal supervision, refused to discharge a patient with acute empyema from the hospital until he has been cured.

5. *The Restoration of the Functional Capacity of the Lung of the Involved Side.*—From a study of our end results the restoration of the functional capacity of the lung upon the involved side would seem to depend upon two factors: (a) upon the time after the development of the disease at which primary treatment is instituted and (b) upon the period of post-operative convalescence. Our records show that patients admitted for primary treatment from one to six months after the development of empyema have retraction of the thorax, thickening of the pleura, obliteration of the costo-diaphragmatic sulcus and fixation of the diaphragm; and therefore diminished functional capacity of the lung; that patients admitted for primary treatment early in the disease are less prone to these conditions. I have examined by physical methods, by the fluoroscope, by X-ray plates and by functional capacity tests about 130 patients in the above series—and anywhere from two months to several years after their primary treatment. The results of these examinations show that when obliteration of the cavity and healing of the sinus takes place promptly there is no retraction of the chest, no drooping of the shoulder, no scoliosis, no thickening of the pleura, and in rare instances only, any fixation of the diaphragm; and no diminution in the functional capacity of the lungs; in other words, restoration to the normal is complete. On the other hand, when convalescence has been prolonged, *i.e.*, when the obliteration of the cavity and the healing of the sinus has required months,

retraction of the chest, thickening of the pleura, fixation of the diaphragm and diminished functional capacity of the lung have been relatively common. It seems clear therefore that in order to restore the involved side to normal we should aim at early primary treatment and prompt cure.

6. *The Certain Cure of Chronic Empyema with a Low Mortality.*—Our previous remarks show the enormous advantages of preventing chronic empyema from the standpoints of mortality, prolonged convalescence and disability. Our experience and that of others moreover shows that with proper methods chronic empyema may be almost entirely prevented. It is not unreasonable to hope that chronic empyema will disappear as a surgical disease; but that time has not yet come, and those interested in thoracic surgery still see a distressingly large number of cases. It is indeed a difficult surgical condition to treat; and a study of the literature shows that the results of various methods of treatment are none too brilliant and the mortality attending them relatively high. It is well worth while therefore to study the condition as it presents itself and to devise and attempt procedures which may cure it.

A study of the pathology of chronic empyema shows an intrapleural cavity surrounded by an *infected thickened* pleura. The cavity may be single and is usually ovoid; or it may be irregular, longer or shorter prolongations (pockets) extending from the main cavity in various directions. The pleura is invariably infected; not only its presenting surface, but often also, as microscopic sections and cultural studies show, its sub-surface deeper portions. Of the two pleural leaves the parietal pleura is in my experience always thicker than the visceral. That is the usual picture; but there may in addition be one of several bronchial fistulæ communicating with the cavity, or a chronic suppurative focus in the lung or a foreign body or a focus of infection in a rib.

In answer to the question why does the condition persist, there are two chief factors to be taken into consideration. (1) The failure of the lung to expand and (2) the continuance of the infection.

(a) *The Failure of the Lung to Expand and Obliterate the Cavity.*—The causes assigned for the failure of the lung to expand have been chiefly three: (1) The shortening of the trabeculæ of the lung the result of prolonged collapse of the lung combined perhaps with infection (*i.e.*, pulmonary fibrosis), (2) adhesions at the point of junction of visceral and parietal pleuræ and (3) thickened pleura. It is well known, as shown by our experiments upon animals, that a normal lung covered by a normal pleura will expand indefinitely to fill any space within the pleura, provided the thoracic cavity is closed. It is also known that in the human subject a relatively normal lung with nearly a normal pleura will spontaneously expand and obliterate a cavity, even in the presence of an open pneumothorax, the result of a rib resection. Quite different conditions obtain in chronic empyema. Even in cases with simple ovoid cavities (without pockets, etc.), observed with the thoracic cavity widely opened so that any movements of the lung may be seen, the greatest force exerted by the patient in forced expiration is often incapable of expanding the lung in the slightest. There is

therefore a powerful resistance to the expansion of the lung in chronic empyema. It has been clearly shown that the shortening of the trabeculæ of the lung is a rare and insignificant factor in this; for the removal of the other factors enumerated allows in the great majority of cases the satisfactory expansion of the lung. We must look therefore to other factors for the failure of the lung to expand, and we find them I think in the adhesions or union between the visceral and parietal pleuræ at the margins of the cavity and in the thickened, resistant, inelastic pleura. A cross-section of a chronic empyema cavity will usually have in our experience an oval shape but differing from an exact oval in that one side—the visceral or lung side—is shorter than the parietal. The thickened visceral pleura has, then, become shortened and bears somewhat the same relation to the chest wall and parietal pleura as a cord subtending an arc. It is firmly held by its union with the thickened rigid parietal pleura. So long as this union persists the shortened visceral pleura cannot meet the parietal pleura and therefore the lung cannot expand to obliterate the cavity. That this is very largely the explanation for the failure of the lung to expand is shown by the success of three procedures: (1) The Fowler-Delorme, which removes the visceral pleura, thus removing the cord subtending the arc, (2) the excision of the parietal pleura described by myself,† which severs the union between visceral and parietal pleuræ and thereby allows the expansion of the lung and (3) the sterilization of the infected pleura which is followed by the absorption of the thickened pleura.

(b) *The Continuance of the Infection.*—Infection is the cause of the thickened pleura, the thickened pleura is, as we have just shown, the cause of the failure of the lung to expand and obliterate the cavity, the persistence of the cavity is most commonly the cause of the continuance of the infection. There is established therefore a vicious cycle which continues until either the cavity is surgically obliterated or the infection overcome. That infection is the fundamental cause for the persistence of chronic empyema was first completely demonstrated by us in 1913; for after the complete sterilization of a chronic empyemic cavity we allowed the sinus to close, leaving within the thorax a large intrapleural cavity. Subsequent cases showed that this experience was not unique and in 1920 we reported 7 cases‡ in which we succeeded in sterilizing chronic empyemic cavities. In all we closed the sinus, leaving within the thorax an unobliterated cavity; and found that the patients remained well, that the thickened pleura disappeared and the cavities were sooner or later spontaneously obliterated. The cure of the infection will alone therefore result in the cure of chronic empyema; for with the disappearance of the infection the thickened pleura is absorbed, allowing the expansion of the lung and the obliteration of the cavity.

The treatment of chronic empyema to be adequate must consider the above factors. The Estlander and Schede operations are designed to obliterate the cavity by bringing the thoracic wall in contact with the lung. The Fowler-

† Annals of Surgery, July, 1920.

‡ Annals of Surgery, July, 1920.

Delorme operation is designed to obliterate the cavity by allowing the lung to expand to meet the thoracic wall. In both groups of procedures the obliteration of the cavity is the primary object, the control of infection a secondary consideration. The excision of the parietal pleura, combined with the Carrel-Dakin treatment as practiced by us, was designed both to aid in the obliteration of the cavity and to control the infection; and it has been shown that complete sterilization of the cavity with closure of the sinus may precede obliteration of the cavity. The simple sterilization of the cavity and the wide exposure of the cavity combined with sterilization (the latter so far as I know first practiced by M. R. Reid in Baltimore and later brilliantly carried out by W. L. Keller) are procedures primarily designed to control the infection, the obliteration of the cavity being the secondary consideration—and occurring spontaneously so soon as the infection is controlled. In a consideration of these various procedures account must be taken of the mortality, of the certainty of cure, of the mutilation and of the resultant functional disability of the lung. Personally we have employed the Estlander or Schede operation in only two cases, for the mortality, the mutilation and the functional disability of the lung have seemed to us great disadvantages. We have made use of three procedures, the simple sterilization of the empyemic cavity with subsequent closure of the sinus; the excision of the parietal pleura combined with sterilization of the cavity and the wide exposure of the cavity by rib division followed by sterilization of the cavity and secondary closure. The two former procedures are applicable in the relatively small simple cavities; the latter in the large complicated cavities. The results we have obtained by the use of these procedures will be given in our summary.

Summary.—From a study of all the foregoing factors we may attempt to outline methods of treatment which in our experience most nearly meet the conditions enumerated in our opening paragraph.

1. Early diagnosis in acute empyema is desirable for failure to make an early diagnosis and institute prompt treatment favors the development of serious complications, increases the mortality and predisposes to prolonged convalescence and chronicity.

2. An early surgical consultation having been obtained, the most careful physical and X-ray examinations should be made for the purpose of determining the presence or absence of complicating conditions. It has been shown that the presence of bronchopneumonia in the lung of the affected or the contra-lateral side, the presence of bilateral empyema, lung abscess, pericarditis, peritonitis, etc., affect profoundly the prognosis and often determine the kind of surgical procedure. The intra-pleural fluid should be examined to determine its character and the kind of infecting organism. It is not clear to us that aspiration drainage has any disadvantages if done without the production of a pneumothorax and under local anæsthesia over simple aspiration, and we can see no good reason for waiting, if a fluid is not purulent but contains many leucocytes and organisms, for frank pus to develop.

3. In infants and young children, in adults very ill with grave toxæmia, and in all cases in which physical and X-ray examinations show or suggest the presence of pneumonia, either lobar or lobular, in the lung of the affected or contra-lateral side or other pulmonary complications, aspiration drainage promptly done under local anæsthesia and without the production of surgical pneumothorax is in our opinion the procedure of choice. Its advantages are that it causes the least possible trauma, it avoids surgical pneumothorax which in the presence of pulmonary complications is a grave condition, and it permits continuous, air-tight, gentle suction drainage and sterilization of the cavity. Its one disadvantage is that the presence of fibrin clots which fail to pass readily through the tube sometimes makes the post-operative management troublesome; yet we can say from a fairly large experience that this difficulty can be overcome, and without the necessity of further operative procedures. It has materially reduced the mortality in the dangerously ill of all age groups, but particularly in infants and young children, as we shall presently show.

4. In adolescents and adults not desperately ill and with empyema localized in the sense that adhesions between visceral and parietal pleuræ have formed of sufficient strength to prevent the ill effects of open surgical pneumothorax, aspiration drainage need not be insisted upon and rib resection may be performed. But if rib resection is performed, provision should be made for immediate continuous air-tight suction drainage. In the past year we have had one fatality due clearly to acute surgical pneumothorax, the result of an open sucking wound following a rib resection.

5. The proper post-operative management of acute empyema is of great importance. Air-tight suction drainage, sterilization of the empyemic cavity, continuous hospital treatment until it has been proven that the empyemic cavity is obliterated and proper pulmonary gymnastics will result in a lowered mortality, in a short convalescence, in a lessened tendency to chronicity and in less functional disability.

Let me conclude this paper with a statement of the results obtained by myself and my associates, Drs. M. R. Reid and B. N. Carter, in the treatment of empyema. The total number of cases treated was 125, of which 83 were acute empyema and 42 chronic empyema. One hundred and twenty-five cases were operated upon with 19 deaths, a mortality of 15 per cent.

An examination of our mortality shows the following:

1 age 30, died the day of operation. No autopsy.
1 age 49, died the day after operation. Autopsy. Bilateral bronchopneumonia; purulent pericarditis.
1 age 5 weeks, died 10 days after operation. Autopsy. Septicæmia. (Proven.)
1 age 32, died 3 days after operation. Autopsy. Bilateral bronchopneumonia.
1 age 36, died 30 days after operation. Autopsy. Lung abscess opposite side.
1 age 42, died ? days after operation. Autopsy. Primary carcinoma of lung.
1 age 47, died 21 days after operation. Autopsy. Embolism, infarction, gangrene lung—following repair arteriovenous fistula.

1 age 20, died ? days after operation. Autopsy. Bilateral empyema, bilateral lung abscesses.
1 age 1–½, died 10 days after operation. No autopsy. Symptoms of pulmonary embolism.
1 age 5/6, died 35 days after operation. No autopsy. Bilateral bronchopneumonia.
1 age 2, died 30 days after operation. No autopsy. Cause unknown.
1 age 2, died 12 days after operation. No autopsy. Cause unknown.
1 age 2, died 27 days after operation. No autopsy. Bilateral pneumonia; septicæmia. (Proven)
1 age ⅔, died 61 days after operation. No autopsy. Cause unknown.
1 age 23, died ? days after operation. No autopsy. Septicæmia. (Proven)
1 age 33, died 4 days after operation. Autopsy. Bilateral bronchopneumonia.
1 age ⅔, died 16 days after operation. No autopsy. Cause unknown.
1 age 40, died immediately after operation. No autopsy. Shock following extensive Schede operation.
1 age 31, died ? days after operation. No autopsy. Septicæmia; (Proven) acute surgical pneumothorax.

Two deaths in this series (carcinoma of lung; gangrene of lung) should be excluded.

The above data include our total experience. When we compare with them our statistics since we have become interested in the subject we find that our results have vastly improved in at least three directions: (a) In lowering the mortality in all age groups, but especially in children under five. As previously noted, the mortality of the entire series for this group was 24 per cent. In our recent series (15 cases) the mortality has been 6.6 per cent. This reduction in the mortality has been due we believe in large part at least to more careful examination before operation, to the substitution of aspiration drainage with local anæsthesia for rib resection and to more careful post-operative supervision. We are, however, aware that the lowered mortality may in part be due to the less frequent presence of complicating conditions. (b) In preventing the development of chronic empyema. Since we have insisted in the past three years that no patient leave the hospital until he is cured, we have had no instance of chronic empyema develop from an acute empyema which we have treated. This we can say after a careful study of the late results in our cases. The criteria for a cure must be rigid. The lung must be proven by physical and X-ray examinations to have completely expanded, and the cavity therefore completely obliterated and the sinus tract healed. Under these conditions we have never yet observed the recurrence of the condition. (c) In the cure of chronic empyema with a low mortality. In our personal series of 42 cases of chronic empyema there have been 35 cases of non-tuberculous chronic empyema and 7 cases of proven tuberculous empyema. Of the 35 cases of non-tuberculous chronic empyema 30 have been operated upon, the operation consisting of either (1) rib resection and sterilization of the cavity, (2) of excision of the parietal pleura followed by sterilization and (3) of wide exposure of the cavity by rib division, sterilization and secondary suture. Five have not been operated upon, the treatment consisting of the sterilization of the cavity through the

original sinus tract. In these 35 cases there has been no mortality. The results in all are known. Twenty-nine have been healed and are well from 1 to 6 years after operation, 2 are healed and well less than 1 year after operation, 4 are still under treatment in the hospital and will undoubtedly be cured. Our experience is far different in the cases of tuberculous empyema. Of the 7 cases in our series all were operated upon, the operations consisting of rib resection with attempts at sterilization in 5, and extensive Schede operations in 2. Following operation 6 patients recovered; 1 died of shock following a Schede operation. Of the six patients who recovered 1 was living and greatly improved in health 2 years after operation, but continued to have a discharging sinus, 4 are known to have died from 6 months to 2 years after operation and one has not been heard from. In none of these had the sinus healed at the time of death. It would appear therefore that the cure of non-tuberculous chronic empyema is quite possible and with a low mortality; the cure of tuberculous empyema remains a problem which still requires serious study.

EXTERNAL DUODENAL FISTULÆ*

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Duodenal fistulæ may be classified into two varieties, the internal and the external. The internal are by far the more common. Courvoisier and Naunyn [1] collected 384 cases of internal biliary fistulæ of which 108 connected with the duodenum. This type of fistula does not concern us here. The external fistula, the group in which the duodenum is connected to the skin by a sinus tract, may be divided into two classes—those having their origin from the peritoneal portion of the duodenum and those arising from its retroperitoneal areas. The former occur with greater frequency and usually arise in the first portion of the duodenum, more rarely, the second. These duodenal fistulæ cannot be as rare as one would gather from a review of the literature, for, when the importance of the duodenum is considered surgically, there are ample causes for the appearance of these fistulæ as postoperative complications.

Lilienthal [2] in 1901 reported the first two cases treated by surgical measures for the relief of this distressing condition, and in 1903, von Cackovic [3] was able to collect only six additional cases from the literature, all of which had been treated conservatively and ended fatally. Melchoir,[4] in 1917, added about 14 additional cases. This report, which is a collective review of 53 reported cases and 8 new ones from the records of Mt. Sinai Hospital, seems to verify to a degree the statement of Palmer,[5] that "duodenal fistulæ are neither the rare nor the simple, benign affairs that the silence of the professional pen might lead one to conclude." Pannet [6] (1915) states "that as far as could be ascertained from the writings of the past ten years, a duodenal fistula never healed without surgical aid and if left is invariably fatal, and, moreover, death may be exceedingly rapid."

That duodenal fistulæ are of bad prognostic import has long been recognized. This emphasizes the fact that not only are they serious surgical cases, but if they are to be handled with any degree of success, they must be treated energetically and early, and not when the strength of the patient has been so debilitated by inanition and dehydration that surgical intervention is impossible. External duodenal fistulæ have a mortality greater than any other variety of intestinal fistulæ. This is obvious when the anatomical location and the physiological importance of this structure are carefully considered.

The duodenum receives the gastric contents; into it are emptied the bile, pancreatic secretions, and its own succus entericus. While there is considerable digestive activity in the stomach, its powers of absorption are negligible,

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TABLE I.

Table of Cases of External Duodenal Fistula Gleaned from Surgical Literature.

Case	Surgeon	Date	Diagnosis	Operation	Drainage	Appearance of fistula	Treatment	Course	End result
1	Berg, A. A.....	1907	Carcinoma of pancreas	Cholecyst oduoden-ostomy	?	5 days P. O.	Ant. gastro-enterostomy, with pyloric occlus. 9 days P. O.	Discharge stopped immed. Death 67 days P. O. from Ca.	Died.
2	Berg, A. A.....		Perforated duodenal ulcer	Suture of perforation	?	7 days P. O.	Post. gastro-enterostomy, suture of fistula, 7 days P. O.	3 days later recurrence Suture unsuccessful 10 days P. O., occlus., pylorus.	Died.
3	*Burgess.....		Perforated duodenal ulcer	Drainage of subphrenic abscess	?	Immediate	Suture of duodenum, 5 months P. O.	Cured	Cured.
4	Clark.....	1919	Cholecystitis	Cholecystectomy	Yes	17 days P. O.	Conservative	20 days P. O., fistula healed	Cured.
5	Clark	1919	Cholecystitis	Cholecystectomy Duodenorrhaphy	?	3 days P. O.	Jejunostomy 10 days P. O.	12 days P. O., death	Died.
6	Cheever.....	1915	Rupture of duodenum	Duodenorrhaphy	Yes	5 days P. O.	Irrigation of sinus	11 days P. O., fistula healed	Cured.
7	Davis.....	1918	Duodeno-ureteral fistula	Nephrectomy	?	4 days P. O.	Conservative	8 days P. O., fistula healed	Cured.
8	Erdman.....	1921	Rupture of duodenum	Duodenorrhaphy	Yes	6 days P. O.	Jejunostomy, 8 days P. O.	18 days P. O., fistula closed	Cured.
9	*Esau.....		Rupture of duodenum	Incision, lumbar abscess	?	48 days after injury	Jejunostomy, 4 weeks after injury		Death.
10	*Penwick.....	1900	Rupture of duodenum	None		42 days after injury	Conservative	Fistula discharged for six months	Died.
11	Fink.....	1905	Cholelithiasis	Cholecystectomy	Tamponade	28 days P. O.	Gastro-enterostomy, suture fistula 35 days P. O.	3 days later recurrence. 75 days P. O., suture, perforation. 95 days P. O., discharged	Cured.
12	Hendon.....	1919	Cholangitis	Exploratory	Yes	Immediate	Conservative	5 weeks later, healed	Cured.
13	†Hinton.....	1866	Rupture of duodenum	None		Several months later	Conservative	20 years persistent discharge	Died.
14	Kehr.....		Cholecystitis	Cholecystectomy	Tamponade	8 days P. O.	Conservative	13-22 days P. O., healed	Cured.
15	Kehr.....		Cholelithiasis	Cholecystectomy	Tamponade	5 days P. O.	Suture, 8 days P. O.	Recurrence, 11 days P. O. 16 days P. O., healed	Cured.
16	Kehr		Cholelithiasis	Cholecystectomy	Tamponade	6 days P. O.	Suture, 9 days P. O.	15 days P. O., sutured 3rd time. 17 days P. O., post. gastro-enterostomy	Died.
17	Kehr.....		Cholelithiasis	Cholecystectomy	Tamponade	20 days P. O.	Conservative	43 days P. O., healed	Cured.
18	Kehr.....		Cholelithiasis	Cholecystectomy Duodenostomy	Tamponade	12 days P. O.	Conservative	18 days P. O., healed	Cured.
19	Kelling.....	1922	Carcinoma of stomach	Billroth 1	?	12 days P. O.	Jejunostomy, 8 days P. O.	30 days P. O., healed	Cured.
20	*Knaggs.....	1909	Perforated duodenal ulcer	Incision, psoas abscess		Several weeks later	Posterior gastro-enterostomy, pyloric occlus., 3 mos. P. O.	Immed. cessation of discharge	Cured.

21	*Körte.....	1904	Rupture of duodenum (?)	Suture	Tamponade	60 days P. O.	Suture, perforation. Jejunostomy, 5 wks. P. O.	2 days later, peritonitis	Died.
22	†Krauss.....	1865	Perforated duodenal ulcer	None		?	Conservative	1 mo. after perforation death	Died.
23	‡Kraske.....	1901	Cholelithiasis	Choledochotomy	Tamponade	2 days P. O.	Suture attempted	30 days P. O., death	Died.
24	§Körte			Nephrectomy		?	Conservative	Healed spontaneously,	Cured.
25	†Luneau.....	1870	Perforated duodenal ulcer	None		90 days after perforation	Conservative	18 months later, death	Died.
26	McGuire.....	1919	Cholecystitis	Cholecystectomy	?	9 days P. O.	Jejunostomy immediately	3 wks. later, fistula healed	Cured.
27	Makkas.....	1907	Carcinoma of stomach	Billroth I	?	10 days P. O.	Suture, 15 days P. O.	16 days P. O., death	Died.
28	Makkas.....		Pyloric tumor	Billroth I	?	2 days P. O.	Conservative	30 days P. O., death	Died.
29	Makkas.....		Tumor of stomach	Billroth II	Tampon	6 days P. O.	Conservative	10 days P. O., death	Died.
30	Merk.....	1902	Cholecystitis	Cholecystectomy	Tampon	15 days P. O.	Conservative	70 days P. O., fistula healed	Cured.
31	Mayo.....	1904	Perforated duodenal ulcer	Suture, gastro-enterostomy	Yes	?	Conservative	Death	Died.
32	Mayo.....		Perforated duodenal ulcer	Suture	Yes	?	Conservative	Healed	Cured.
33	Mayo.....	1914	?	Nephrectomy	?	5 days P. O.	Conservative	14 days P. O., death	Died.
34	Mayo.....		Carcinoma of kidney	Nephrectomy		5 days P. O.	Conservative	10 days P. O., death	Died.
35	Mayo.....		?	Nephrectomy	?	?	Conservative	14 days P. O., death	Died.
36	Mayo.....		Nephrolithiasis	Nephrectomy	Tampon	2 days P. O.	Suture, fistula immed.	Uneventful recovery	Cured.
37	Melchoir.....	1914	Carcinoma of stomach	Billroth II	Tampon	12 days P. O.	Conservative	2 years P. O., fistula healed	Cured.
38	Meyer.....	1920	Cholecystitis	Cholecystectomy	Tampon	?	Conservative	7 mos. P. O., fistula healed	Cured.
39	Palmer.....	1918	Carcinoma of stomach	Billroth II	Yes	8 days P. O.	Conservative	24 days P. O., fistula healed	Cured.
40	Palmer.....		Cholelithiasis	Cholecystectomy Duodenostomy	Yes	6 days P. O.	Conservative	28 days P. O., fistula healed	Cured.
41	Pannett.....	1914	Perforated duodenal ulcer	Duodenorrhaphy	Yes	4 days P. O.	Jejunostomy 8 days P. O.	15 days P. O., fistula healed	Cured.
42	*Payr.....			Nephrectomy		2 years P. O.	Suture	Recovery	Cured.
43	*Perry and Shaw		Perforated ulcer	None			Conservative	6 mos. persistent discharge	Died.
44	Rigby.....	1911	Tuberculosis of kidney	Nephrectomy	?	Few weeks P. O.	Conservative	Healed	Cured.
45	Rigby.....		Perforated duodenal ulcer	Drainage of abscess	Yes	3 days P. O.	Conservative	9 days P. O., fistula healed	Cured.
46	†Rintel.....	1867	Intestinal tuberculosis	None		2 days after illness	Conservative	Death after 1 month, inanition	Died.
47	†Steaten.....		Perforated duodenal ulcer	None		?	Conservative	Death after 3 weeks, inanition	Died.
48	*Telford.....	1912	Perforated duodenal ulcer	Incision, abscess		5 days P. O.	Suture and gastro-enterostomy	6 days P. O., death	Died.
49	Thevenard.....	1913		Nephrectomy		?	Beck's paste. Gastro-enterostomy	9 days P. O., healed	Cured.
50	Turner.....	1913	Perforated duodenal ulcer	Duodenorrhaphy	Yes	2 days P. O.	Conservative	8 days P. O., death	Died.
51	Turner.....		Cholelithiasis	Cholecystectomy	Yes	3 days P. O.	Conservative	5 days P. O., death	Died.
52	Von Cackovic	1903	Sarcoma of kidney	Nephrectomy	Tampon	10 days P. O.	Jejunostomy 17 days P. O.	19 days P. O., death	Died.
53	†Wagner.....	1906	Perforated duodenal ulcer	None		8 months after perforation	Conservative	7 months later, death	Died.

TABLE I. (*Continued*)

Table of Cases of External Duodenal Fistula Gleaned from Surgical Literature.

From the Surgical Services of Mt. Sinai Hospital, 1913-1923.

Case	Surgeon	Date	Diagnosis	Operation	Drainage	Appearance of fistula	Treatment	Course	End result
54	Case No. 672	1913	Cholelithiasis	Choledochotomy Duodenorrhaphy	Yes	5 days P. O.	Gastro-enterostomy with pyloric occlusion, 7 days P. O.	15 days P. O., death, inanition	Died.
55	61-74	1914	Cholelithiasis	Cholecystectomy Duodenotomy	Yes	7 days P. O.	Gastro-enterostomy with pyloric occlusion, 7 days P. O.	8 days P. O., death	Died.
56	60-14	1915	Cholelithiasis	Choledochotomy	Yes	29 days P. O.	Conservative	43 days P. O., fistula healed	Cured.
57	61-136	1916	Cholelithiasis	Left hepatoduodenotomy	Yes	16 days P. O.	Gastro-enterostomy with pyloric occlusion, 21 days P. O.	2 hours later, death	Died.
58	61-181	1920	Cholelithiasis	Cholecystectomy Duodenorrhaphygastro-enterostomy with pyloric occlusion	Yes	7 days P. O.	Jejunostomy 14 days P. O.	20 days P. O., death	Died.
59	4-34	1921	Cholecystitis	?	?	?	Conservative	4 months P. O., healing	Cured.
60	61-103	1922	Cholecystitis	Cholecystectomy Duodenorrhaphy	Yes	5 days P. O.	Conservative	20 days P. O., fistula healed	Cured.
61	41-8	1923	Abdominal pain	Duodenorrhaphy	Yes	5 days P. O.	Conservative	40 days P. O., death	Died.

* Quoted by Melchoir, Ed.
† Quoted by Von Cackovic.
‡ Quoted by Lilienthal.
§ Quoted by Schede.

so with an opening in the duodenum, such as exists in a fistula, not only is there a loss of the intestinal juices, but a loss of practically all food and fluid which has been ingested. Inanition and dehydration soon become marked; in fact, each day makes a material change in the gradual malnutrition of the patient. However, the loss of fluids alone cannot account for the rapid emaciation and debilitation which occurs, for even though the body is supplied sufficiently with fluids, hypodermatically, rectally or intravenously, and some nourishment, admittedly small, is given by nutrient enemata and the addition of glucose to the body fluids, deterioration occurs. There may be several factors partially instrumental in causing the rapid death of these unfortunate individuals. Perhaps not only the loss of the pancreatic ferments and to a less extent, the bile, but the absorption of the various secretory products leaving the duodenum through the open fistulous tract may be responsible. It is well known that pancreatic juice is extremely toxic and it may cause a toxicity incidental to autodigestion which with the absorption of these products causes a general systemic poisoning.

Eisberg [7] from his experimental work on intestinal obstruction states that "damaged intestinal tissue is the deciding factor as regards the lethal outcome." Roger and Garnier,[8] studying the toxins of intestinal obstruction, show that the toxicity of the intestinal mucosa was more than its contents, and that the duodenal mucosa possessed a greater toxicity than the ileum. While the pathological conditions of duodenal fistula and intestinal obstruction are in no way related, there certainly must be some absorption from the necrotic and sloughing walls of the duodenum about the fistula. This may be a contributing element to the toxæmia.

Bearing these various points in mind, Palmer, Cheever [9] and Erdman [10] in their cases have attempted by various means either to absorb the secretions from the fistula as soon as they have been formed, or at least to dilute them by adding water.

Duodenal fistulæ may be caused by a variety of circumstances. They may result secondarily to a traumatic rupture of the duodenum as in the cases of Körte,[11] Esau [12] and Hinton.[13] Here, due to a late necrosis of the duodenal wall, an abscess resulted which by dissection of the tissues finally ruptured externally, forming a fistula. Before 1900, before the period when ulcers were recognized with the accuracy of present-day methods, it was not uncommon for them to rupture, become walled off as an abscess, and subsequently open externally in a region far afield from their origin. For example, in Forster's [14] case, where there was a retroperitoneal perforation, the pus ascended along the great vessels and finally became localized in the neck. Although this case never lived to form a fistula, the possibilities were there nevertheless. In the cases of Wagner [15] and Fenwick [16] swellings appeared in the inguinal region which after spontaneous rupture soon showed that it bore a connection with the duodenum, and when the individual died several months later from inanition, the autopsy showed a sinus running into the second part of the duodenum retroperitoneally. Rarely these fistulæ

occur even after the suture of perforated ulcers, usually, however, only in those cases in which drainage had been used. Varieties of this type are cited by Graham and Mayo,[17] Pannet, Berg [18] and Turner.[19]

Occasionally, they are the direct or indirect consequences of operative interference near the duodenum or upon neighboring organs which have become adherent to it. It is perfectly possible to traumatize the duodenal wall mildly at the time of operation, or to compromise its blood supply by the ligature of vessels essential to its nutrition. This may either escape notice or appear so insignificant as to cause no anxiety. However, this area may become necrotic and slough, subsequently forming the basis for a duodenal fistula. Lilienthal, in his thesis, suggested that the wall might be compromised in dissecting away peritoneal adhesions. Such cases have been recorded, following gall-bladder operations, by Kehr,[20] Fink,[21] Meyer,[22] Merck [23] and others. This was the most common cause in this series and was responsible for 23 cases. It may follow either accidental opening of the duodenum, as in case 41–8, or in transduodenotomies, as in the case of Kehr, where the duodenum was opened to extract a stone from the common bile duct. It may result after stomach resection, either after a Billroth No. 1 or 2, as recorded by Melchoir,[24] Kelling [25] and Makkas.[26] Removal of the right kidney may be followed by a fistula as in von Cakovic's case, where the duodenal wall was compromised with a secondary necrosis. In the cases of Davis,[27] a ureteroduodenal fistula, a piece of mucous membrane was excised, with a secondary opening of the duodenum. In the patients of Mayo,[28] Payr [29] and Thevenard,[30] the duodenum itself was directly compromised by clamps in an attempt to check blindly the hemorrhage from the renal vessels.

The diagnosis of this condition as a rule is not very difficult. The odor and appearance of the dressings are really sufficient to make one suspect the condition. The dressings may suddenly become wet and smell characteristically of stomach contents. This discharge may be so copious as to completely soak the bed linen and mattress. Should the condition be suspected and occur rather early, and at a time when solid food has not as yet been given, methylene blue by mouth will indicate definitely whether or not there is an opening in the intestinal wall by the characteristic color in the discharge staining the dressings.

The discharge, on examination, may or may not contain bile or pancreatic ferments. Von Cackovic, Lieblein and Hilgenreiner [31] thought that the presence of bile was usually significant in placing the position of the fistula as below the papilla of Vater, and that the absence of bile might lead one to conclude that the fistula was supra-papillary. This distinction, if so, might aid from a prognostic standpoint, for lesions above the papilla certainly cannot be as serious as those below. However, this is fallacious. The fistulæ which follow the Billroth 2 operations usually contain bile, and these are excellent examples of supra-papillary fistulæ; besides, under certain conditions there may be antiperistaltic waves in the duodenum, and bile and

pancreatic ferments may be carried retrograde far above the papilla. In the case of Telford and Radley,[32] where the perforation was one inch from the pylorus, bile was secreted after the retroperitoneal abscess was opened, and Payr reports that in spite of the absence of bile and pancreatic secretions, in his case, the lesions were infra-papillary.

Not only does the odor and the appearance of the dressings make one suspect the condition, but the appearance of the skin is rather characteristic. Often within a few hours after the appearance of the discharge, it becomes red, swollen, excoriated, and soon shows signs of being digested. This excoriation of the skin may extend with extreme rapidity over the entire abdomen, often to the back, causing the patient excruciating pain and annoyance. This dermatitis may prove a bar to secondary operations.

To differentiate a duodenal from a gastric fistula at times is difficult. The reaction of the secretion is of little aid, because high duodenal fistulæ are usually acid. However, the appearance and time of the appearance of food contents are rather important. In gastric fistulæ, the food particles, digested but little, are recognizable as such and occur soon after ingestion. In duodenal fistulæ they appear more digested and occur a little later. To distinguish duodenal from high jejunal fistulæ is slightly more difficult. If this question should arise, the patient might be given a corn kernel attached to a string to swallow. The distance from the incisor line of the teeth to the kernel in the fistula might then be measured and the question answered. Cushing [33] found this particularly useful in proving that a certain fistula was jejunal in origin. Of course, one may always have recourse to X-ray examinations by the injection of bismuth into the fistulous tract, but these procedures are rarely necessary.

The time of the appearance of the fistula varies. It usually occurs from the fourth to the sixth day, the time at which drainage is either changed or removed. When it is due to a slow necrosing of the duodenum with a separation of the slough, it may occur as late as a month after operation.

The amount of discharge is dependent upon the calibre and tortuosity of the fistula and the food ingested. The discharge varies directly with the diameter of the duodenal opening, and inversely to the tortuosity of the sinus. The fact that some patients may survive for years with a duodenal fistula shows that occasionally it may be quite harmless, but the records of death within a few days after its appearance show the alarming character which these fistulæ may adopt. The prognosis of the fistula depends upon its size and is influenced largely by the physical status of the individual. The operations after which these fistulæ develop as a rule have been long, tedious and difficult. The stamina of the patients has been definitely impaired, and coupled with the great loss of nourishment and the absorption of the intestinal juices, they fall easy prey to intercurrent infections such as pneumonia.

The treatment of external fistulæ is by far the most interesting and important phase of the entire subject, because the diagnosis is usually rather

simple. Like so many other surgical complications, the prophylaxis of this condition is better than its cure. In operating upon or in the vicinity of the duodenum, it is imperative that the wall is not compromised; if it is, it must be carefully and skillfully repaired by sutures.

The majority of cases where fistulæ have resulted have been drained, and the appearance of duodenal contents invariably dates from the removal of the tampon, tube, dam or gauze. Wherever possible, pressure must not be exerted against the suture line by drainage material of any variety. For this undoubtedly not only devitalizes the duodenal wall by pressure, but as Horsley [34] has suggested, the lymph which ordinarily aids in sealing the duodenal closure is absorbed by the capillarity of the drain. A reopening of a sutured duodenum after an acute perforation of an ulcer which has not been drained is exceptional. It is rather interesting to note that when gauze as drainage was placed against an open duodenal ulcer, fistula resulted. In a series of 200 cases of perforated duodenal ulcer collected by Struthers,[35] the majority of which were treated by simple suture, and if drained, the point of drainage was usually in the pelvis, only three cases of duodenal fistulæ resulted. These three cases in which the perforation was not closed at the time of operation died within a few days from the emaciation and asthenia of a leaking fistula. In case 41–8 the duodenum was sutured very carefully in two layers and a reinforcing layer of omentum sewed over it, and a rubber dam was placed down to the suture. While this drainage may not have been responsible for the breakdown of the suture, it may have been a contributing element. The same occurred in the cases of Cheever and Erdman. There is always a potential danger from peritonitis, either from soiling or subsequent leakage after the intestinal canal has been opened, but this should not be any greater following a duodenotomy with duodenorrhaphy than that following a perforated duodenal ulcer, a gastro-enterostomy or a stomach resection, and a drain is rarely placed to the intestinal suture line in these cases.

Resection operations upon the stomach, especially the Billroth 2, which leaves a free duodenal stump, are always attended by the possibility of duodenal leakage and fistula formation. Kelling [36] claimed that these fistulæ were caused in part by a damming back of the duodenal secretions into the blind end and that this increased back pressure caused a breaking strain on the suture line. He therefore advised enterostomy between the loops of a gastro-enterostomy so as to insure proper drainage of the duodenum, and in fifty-three cases in which he used this method, only one fistula resulted. Lewitt [37] tried to accomplish the same by suturing the duodenal end into the adjoining jejunal loop in the Polya operation. There is no doubt that these precautionary measures are extremely good, but they materially lengthen an operation which even in skilled hands is rather a long procedure. Köttner [38] believed that the danger of duodenal leakage could be avoided by a very careful covering of the duodenal stump with peritoneum and further reinforcing this by sutures against the pancreas, omentum or gall-

bladder. Bier [39] recommends a very accurate purse-string suture of the duodenal stump with inversion so that it is completely peritonealized.

There is still another point of prophylactic interest. It is a question of procedure when the duodenum has been injured either through external trauma or torn at the time of operation. Would it be better to perform a gastro-enterostomy with pyloric occlusion in addition to the simple suture of the duodenal wound? The value of this operation is discussed subsequently in the treatment by operation of external duodenal fistulæ. It is rather hard to draw any valuable statistics from the recorded cases of duodenal rupture because the mortality is over 95 per cent. Of course, if the opening is small the suture line may be relied upon with safety. But if the opening is large and the wound must be drained, it might be better policy to divert the gastric current. In speaking of traumatic injuries to the posterior duodenal wall, Summers [40] strongly recommends this procedure. Guibe,[41] in a collected series of 134 cases of traumatic rupture and contusion of the duodenum, reports 129 deaths and five cases living. These fail to throw any light as to the advisability of operative procedure. An abstract of these five cases of recovery is as follows:

Case I.—Godwin, 1905, Lancet, vol. ii, p. 1108.—Crushed by wagon wheel, signs reduced to a minimum. Operation at the end of six hours. Rupture of great omentum, rupture of the first part of the jejunum and rupture of the anterior surface of the duodenum near its termination. Closure of the two intestinal wounds, that of the duodenum being treated like a pyloroplasty. Lavage of the peritoneum and drainage. Cured.

Case II.—Herezel, Hildebrandts Jahrebericht für 1896, p. 691.—Woman of thirty-six, contusion of her abdomen against the angle of a piano. Jejunum 18–20 cm. from its origin twisted on its axis where there was a tear at the duodeno-jejunal angle. Suture. Cure.

Case III.—Krantz, H. W., 1904. Inaugural Dissertation, Leipzig.—Nineteen years old, crushed by a carriage. Marked shock. Operation one hour later. Tear at the level of the duodeno-jejunal angle with denudation of the serous coat for about 5 cm. Suture. Reunion of serous membrane impossible. Tamponade. Cured.

Case IV.—Meerwein, H., 1908. Beitrage zur klin. Chirurgie, Bd. 1.123, pp. 495–517.—Female, fifty years old, slid and fell on corner of a chair. Operation at the end of eight hours. Marked contusion of duodenum. Resection of the contused segments. Closure of both ends. Gastro-enterostomy. Duodeno-enterostomy. Cured.

Case V.—Steinthal, 1908. Münchner med. Wochenschr., pp. 169–170.—Eighteen years old. Hit by carriage, wheels passed over abdomen. Operation twelve hours later. Large tear in the mesocolon and almost complete tear in third portion of the duodenum. Suture. Gastro-enterostomy. Lumbar drainage. Cured in spite of an intestinal obstruction which necessitated a second intervention.

In addition, gastro-enterostomies were performed by six other surgeons in this collected series. A case of Kraske's died of pulmonary abscess. Monyhan's case died three months later from perforation of the duodenum by a Murphy button, which had lodged there from a button gastro-enterostomy. Krantz's case died soon after operation. Makins' case died on the ninth

day. Hagen's case died in thirty-six hours from peritonitis. Schwartz's case died an hour after operation.

The treatment of duodenal fistula is either conservative or operative. If the discharge keeps within normal limits, does not progressively increase, the strength of the patient does not appear to ebb rapidly, and from the nature of the operation it is known that that opening in the duodenum cannot be very large, conservative treatment is to be preferred. For the large percentage of smaller fistulæ, especially those which occur after gall-bladder operations, invariably heal if the sinus is dressed and treated with care. There are several essential basic principles in the conservative treatment which must be scrupulously and rigidly followed if hope is entertained of curing the condition. It is of prime importance that the discharge from the opening must be diminished as much as possible. What secretion there is must be rendered harmless, either by diluting it or aspirating it as soon as it is formed. Meanwhile, the skin must be protected from the ravages of digestive action of the intestinal juices, and at the same time the nutrition and water balance of the patient must be carefully maintained. All fluids should be immediately stopped by mouth. This naturally will lessen materially the discharge coming from the fistula, but there still will be the gastric juice and the succus entericus of the duodenum with or without the presence of bile and pancreatic ferments. The secretion of these juices is stimulated by "secretin," which is liberated by the saliva.[42] If all food and fluid is stopped by mouth, the salivary gland will not be stimulated, and there will be very little reflex flow from the duodenum, liver and pancreas. The secretion of gastric juice is partially controlled by the kind and amount of food ingested, and in a fasting stomach this amount is minimum. The little there is may be neutralized by alkalis given by mouth in frequent and small amounts.

To further inhibit the secretion of these juices some surgeons have given atropine and sodium fluoride, but this as a rule is not well tolerated and is of little value. Palmer and others have given mineral oil by mouth, believing that the fat might have an inhibiting influence on the secretion of gastric juice and, by mechanically coating the fistulous tract, lessen the digestive action of the pancreatic juice on the surrounding tissue.

Although the secretions from the duodenum may be greatly diminished by these various procedures, they cannot be entirely stopped. The treatment of the portion which remains is very important. If it is small in amount it may be neglected. If sufficient in quantity it may be rendered less harmful by diluting it with the addition of fluid introduced into the fistula, or by removing it as soon as formed either by swabs or by suction.

The dilution of the secretion by the addition of fluid was not very successful in the hands of Palmer. He used a drop irrigation of one per cent. sodium fluoride solution for about four days, changing the dressings, but had to discontinue it because the fluid ran around to the back macerating the skin. Cheever was more successful with his method and noticed an

immediate cessation of the destructive processes coincident with a general improvement of the condition. In his case, the sinus was continually irrigated with sterile water for five days and five nights; the outflow being conducted into receptacles by means of banks of rubber tissue kept adherent to the skin of the wound by chloroform. It has also been suggested to keep the patient immersed in a continuous warm bath, but this is usually not very practical. In case 61–103, the secretions were gently wiped away whenever they appeared in the opening of the fistula, the open wound being continually watched by an attending nurse. And although this fistula occurred after a duodenorrhaphy where the opening in the duodenum was moderately large, the fistula healed in fifteen days. Erdman ingeniously employed a continuous suction to keep the sinus clean. He reintroduced the collected secretions through a jejunostomy performed three days after the appearance of the fistula. By this method of continuous aspiration he avoided the excoriation of the skin.

It is of great importance that the area about the wound be protected from the digestive action of the intestinal juices because not only does it cause pain to the patient, but all subsequent operations must be done through an infected field. In the beginning when the skin is comparatively dry, it might be coated with a film of paraffin wax of low melting point applied hot to the skin. If the skin is ulcerated the various protective, non-irritating ointments may be used with beneficial effects.

If the fistula is small, the sinus might be snugly packed. This was used by Henden [43] and Kehr very effectively. This is never applicable to large fistulæ and should never be attempted because the mere pressure of the packing, together with the chemical irritation, will cause further sloughing and necrosis.

While the caloric value of the food given may be low, the water balance must be absolutely maintained. Fluids may be given by enemata, Murphy drip, hypodermoclysis or intravenously. Glucose infusions, from 5 to 20 per cent., in addition to supplying water, add a small amount of nourishment. Nutrient enemata, about three a day, may tide the patient over until the fistula has closed, when the frequent feeding of small amounts of selected foods with very little bulk may be instituted.

Recently, Meyer and Einhorn [44] have reported a case of a rather mild fistula occurring after a very difficult cholecystectomy which persisted for about five months. This fistula finally closed by feeding the patient through a duodenal tube which X-ray proved to have slipped into the jejunum. This no doubt is a very excellent way of maintaining the nourishment of the patient and diminishing the secretions of the fistulous tract, permitting the sinus to heal by granulations. In case 41–8 an attempt was made to pass a duodenal tube beyond the fistulous opening on two occasions without success. While this method may not be useful in the really acute cases, it certainly has a very definite indication where the fistulæ have been of rather a long-standing nature.

If the fistula occurs after an operation in which the duodenum has been purposely opened as in a duodenostomy, or after a Billroth 2, it is reasonable to suppose that due to infection and sloughing the entire extent of the duodenum which has been sutured may open. This is also true after the duodenorrhaphies for rupture of the duodenum or a reopening of recently sutured ulcer perforations of the duodenum. While the operative statistics in these cases are no better at the present time than those treated conservatively, they no doubt could be improved. To begin with, operation must be done early at a time when the patient is not too debilitated from the prolonged effects of drainage from the duodenum, and what is more important, a proper operation must be instituted.

The various operative procedures which may be used are: suture of the duodenal opening, suture of the duodenum with gastro-enterostomy with or without pyloric occlusion, and jejunostomy.

Simple suture of the perforation seems ideal, but it is absolutely useless when the pathology of the fistula is considered. The tissues about the opening in the duodenum are devitalized. The sinus is long, deep, chronically infected, favoring the formation of a dead space. The sutures may seemingly hold for the time being, but the tissues seem to have lost their ability to heal over, and in a few days, aided by the pressure of the duodenal contents, the perforation recurs. The condition is worse now than it was before an attempt was made to better it. Kehr tried suture three times in one case, Berg twice, Makkas and Kraske once, all with the same result—failure. Certainly, suture is worthless when the fistula is a peritoneal one.

Lilienthal (1901) suggested that if the duodenal and gastric secretions be diverted from the recently sutured perforation, the opening might heal. He suggested gastro-enterostomy. This operation without pyloric occlusion for duodenal fistula is worthless.

Kelling's experiment on gastro-enterostomized dogs with normal stomachs has shown that most of the ingested food went through the pylorus and not through the stoma, and after duodenal and jejunal fistulæ had been formed, that most of the food came through the former. Delbet [45] proved the same by suturing the oral end of the upper jejunum into the abdominal wound and the anal end into the stomach. These points have further been proved by the röntgenological studies of Canon and Blake [46] and the dye experiments of Borsczeky.[47] In addition to these experimental data, there is the added proof of the unfortunate clinical evidence in the cases of Berg, Cameron,[48] Fink, Kehr and Telford showing that a simple gastro-enterostomy without pyloric occlusion is useless. With pyloric occlusion, it is theoretically the operation of choice.

In 1903, Berg [49] advocated this operation for duodenal fistulæ, and in 1907, reported a case which had a dry fistula immediately after the operation, and remained dry until death ensued, seventeen days later, from the cachexia of a carcinoma. Knaggs reports a successful secondary operation for a fistula which had been draining for three months. It is interesting

to note that after the Billroth 2 operation which really fulfills all the requirements of a gastro-enterostomy with pyloric occlusion, that duodenal fistulæ develop, probably from the back pressure of the duodenal contents. Makkas and Kelling have reported instances of this after stomach resection.

In case 61–181 (Mt. Sinai Hospital, see table, No. 53), an operation was performed where cholecystoduodenostomy had already been made. After suturing the opening in the duodenum, as a prophylactic measure against the possibility of duodenal leakage, a pyloric occlusion with a button gastro-enterostomy was performed. In spite of this precaution a duodenal fistula developed seven days later. In case 672, a gastrojejunostomy with pyloric occlusion was performed as soon as the fistula developed, but the fistula continued to discharge until the death of the patient seven days later. These two cases are fairly good evidence that this operation does not guarantee the absolute closure of the fistula. Nor does its performance in cases where the duodenum has been opened guarantee a permanent closure. This point should be clearly borne in mind when advocating this operation for traumatic rupture of the duodenum.

In addition, this operation cannot be performed without a certain degree of shock. Although it may be done rapidly with a Murphy button, adhesions must be divided, new paths of infection are probably opened, with the end result that the patient often dies of the operative interference. This was probably the cause of death in case 61–74 and in case 61–136, where the patients died within twenty-four hours after the operation. There are seven instances in which this operation has been performed, and only one case of permanent cure.

Jejunostomy until recently has been very seriously condemned. Körte and Esau employed it four and five weeks after the rupture of the duodenum. Cackovic fourteen days after the fistula had appeared. All the cases terminated fatally, but this would probably have happened with any other procedure. More recently, Kelling, Pannet, Erdman and McGuire [50] have used it with excellent results. Jejunostomy is an operation which is comparatively simple. It may be performed expeditiously through a new incision without any fear of spreading the infection and with a minimum amount of shock and hemorrhage. It forms a channel which may be used immediately for the introduction of food and fluid. It must be admitted, however, that the gastric section and some of the duodenal juice may still pass through the fistula, but the amount of this secretion may be materially reduced by employing those measures previously mentioned under the head of the conservative treatment. There is very little chance of food introduced through the jejunal opening reappearing through the duodenal fistula if certain precautions are taken. The jejunostomy must be made at a sufficient distance from the duodeno-jejunal angle. And all fluid food introduced should be given slowly and by drip. For example, Kelling introduced 250 c.c. of fluid by drip so that it took one and one-half hours for its absorption. The advisability of reintroducing into the jejunostomy the secretions

obtained from the fistulous opening by aspiration is still problematical. Erdman did it in his case with excellent results. There is no doubt that the body loses something essential to its well being through the loss of bile and pancreatic ferments. Kelling, to compensate for the latter, gave his patient pancreatin through the jejunostomy.

The treatment of retroperitoneal fistulæ at present seems to be confined to those which occur after nephrectomy. Mayo [51] seems to be of the opinion that the cases which develop within a few days after operation should receive immediate surgical intervention, and he cites three cases treated by non-surgical methods which died within fourteen days from inanition. He advises simple suture of the perforation, reinforced by omentum. This operation is performed by mobilization of the duodenum through the abdominal route. Payr reports a successful suture of a fistula developing two years after nephrectomy. Thevenard reports rather an unusual fistula occurring ten years after nephrectomy complicated by signs of a pyloric obstruction. A simple gastro-enterostomy was performed, the lumbar fistula being filled with Beck's bismuth paste, and in nine days the fistula was closed. Küste [52] and Davis were able to heal their cases of rather small fistulæ in a few days. Retroperitoneal fistulæ seem to follow the rule of peritoneal ones; if large, operative procedure; if small, conservative measures. The number of cases reported are so small that no definite conclusion as to the operative procedure to be employed can be drawn.

The records of Mt. Sinai Hospital of New York show that eight cases of external duodenal fistula have been cared for in its wards up to the present time. A brief report of these cases is herewith presented.

CASES OF EXTERNAL DUODENAL FISTULA FROM THE SURGICAL SERVICES OF MT. SINAI HOSPITAL, NEW YORK

Case I.—R. L., female, aged sixty-one. No. 41–8. Admitted January 12, 1923. Died March 4, 1923. Diagnosis: Abdominal pain after cholecystectomy. Operation: Exploratory laparotomy. Duodenorrhaphy. Complications: Duodenal fistula, erysipelas of face and back, bronchopneumonia.

History: Epigastric and right upper quadrant pain for three weeks. Two months before admission, cholecystectomy and choledochotomy for acute cholangitis. Had severe attacks of abdominal pain while in the hospital which were controlled only by morphine. Wassermann negative. Physical examination negative except for scar of previous operation.

February 1, 1923, adhesions freed from gall-bladder bed. Common duct free of stones, foramen of Winslow closed. Duodenum mobile, and in lifting it up to palpate the region of papilla, retractor tore a hole in the first portion of the duodenum. Duodenorrhaphy by two layers of chromic catgut, a third suture line bringing over the mesentery and over this the omentum. Drainage. A rubber dam drain down to the duodenum, closure of the wound in layers. Three days post-operative, pain in the wound, tenderness, fullness about the incision. Free drainage of bile. On Murphy drip. Five days post-operative, dressing soaked with bile, skin edges reddened and inflamed. Duodenal fistula suspected. Skin protected with zinc oxide ointment. Six days post-operative, rubber dam drain removed; methylene blue by mouth appeared through the sinus in a very few moments. Reaction

of secretion acid. Fluids stopped by mouth. Wound dressed every four hours by packing. Sixteen days post-operative, packing unsatisfactory. Marked leakage. Attempt to pass duodenal tube, X-ray showed it in stomach. Patient given nutrient enemata. Discharge through fistula slightly less. Twenty days post-operative, rise in temperature with appearance of facial erysipelas. Condition of patient is not satisfactory. Fistula is still discharging a fair amount. Twenty-eight days post-operative, all dressings removed and secretions from fistula removed by gentle sponging as soon as they appeared at the external orifice of the sinus. Erysipelas had spread to back. Twenty-nine days post-operative, an attempt made to reintroduce a duodenal tube, and it was thought that after the feeding of peptonized milk which was given a few ounces at a time, there was no leakage. Patient's condition poor. Thirty-seven days post-operative, duodenal tube discontinued because X-ray showed it to be in the stomach. Semi-solid food given by mouth. Discharge appeared to be less. Patient's condition desperate. Thirty-nine days post-operative, acute otitis media. Forty days post-operative, right lobar pneumonia with death.

Autopsy: Acute purulent bronchopneumonia; chronic adhesive pericarditis; fistula of duodenum between duodenum and sinus tracts; cholecystectomy.

Case II.—E. W., female, aged sixty. No. 61–103. Admitted May 9, 1922. Discharged June 10, 1922. Diagnosis: Chronic cholecystitis, cholecysto-duodenal fistula. Operation: Cholecystectomy; suture of duodenal fistula. Complications: Duodenal fistula.

History: Indigestion for a period of seven months with anorexia and loss of weight, vomiting for past three months after eating once or twice every three days. Physical examination showed an emaciated woman. Liver just palpable. X-ray showed splanchnoptosis, increased peristalsis of the stomach.

May 10, 1922, right rectus incision; first and second parts of duodenum appear infiltrated and gall-bladder connected with the second portion of the duodenum by fistula. Cholecystectomy. Hole in the duodenum closed by chromic gut sutures, which was difficult because of the infiltration and friability of the tissues. Rubber dam drain down to suture line. Large b. m. drain and two layers of iodoform gauze to gall-bladder bed. First day post-operative, gauze removed. Murphy drip 5 per cent. glucose. Five days post-operative, evidently duodenal leakage, skin black and macerated. Nine days post-operative, possibility of performing gastro-enterostomy with exclusion of the pylorus considered but postponed on account of the severe dermatitis. Fourteen days post-operative, considerable leakage of food through the duodenum, but growing less. Eczema of the skin improved. Twenty days post-operative, duodenal fistula appears closed. Thirty days post-operative, duodenal fistula closed for ten days. Condition of patient excellent. Discharged well.

Case III.—L. D., female, aged forty. No. 61–181. Admitted September 23, 1920. Died October 21, 1920. Diagnosis: Cholelithiasis. Cholecystenterostomy. Operation: Cholecystectomy and drainage, suture of duodenal fistula. Complications: Duodenal fistula. Secondary operation: Jejunostomy.

History: Thirteen years ago following an acute attack of pain in the right upper quadrant, patient had a cholecystenterostomy performed and remained free from all symptoms for six years. Seven years ago, patient had acute pain in the right upper quadrant which radiated to the back and shoulder and three weeks before admission this was repeated. She had been jaundiced on several occasions. Physical examination showed a palpable oval mass situated in the right upper quadrant, extending below the costal margin, moving with respiration, and apparently attached to liver.

September 29, 1920, cholecystectomy; duodenal closure; button gastro-

jejunostomy with pyloric occlusion. Right rectus incision. Stomach, colon and duodenum densely adherent to liver and to gall-bladder. Gall-bladder thickened and connected with duodenum through fistula. Inspissated bile and pus in gall-bladder. Adhesions free. Cholecystectomy. Stoma in duodenum closed with several purse-string sutures of chromic. Pylorus occluded with No. 4 Pagenstecher double, and button gastro-enterostomy performed, the intestinal and gastric parts of the button held in place by a No. 3 Pagenstecher. Mesocolon sutured to stoma by No. 1 chromic. Drainage, one tube, one rubber dam, two gauze packings to liver bed. Four days post-operative, considerable discharge of bile. Seven days post-operative, discharge markedly increased, evidently a leak from intestinal suture line. Patient vomiting almost continuously. Eight days post-operative, marked excoriation of skin by profuse discharge. Fourteen days post-operative, jejunostomy under nitrous oxide. Left rectus incision; stomach and intestines adherent to abdominal wall about old wound, but in the previous operation not found. Sutures firm. Jejunum opened one foot from duodenojejunal angle. Tube introduced with three purse-strings No. 3 Pagenstecher, and the suture of the peritoneum to the jejunum. Fourteen days post-operative, vomiting has stopped; patient slightly better. Nineteen days post-operative, patient much worse; 300 c.c. of glucose solution intravenously. Twenty days post-operative, 900 c.c. of glucose intravenously. Twenty days post-operative, death.

Case IV.—M. C., male, aged twenty-seven. No. 41–34. Admitted September 21, 1921. Discharged September 29, 1921. Diagnosis: Healing duodenal fistula. Operation: None. Complications: None.

History: Four months ago, following some gall-bladder operation, patient developed a fistula in his abdominal wound through which food recently ingested passed for a certain period of time and then a constant whitish fluid, occasionally bile-tinged. Physical examination showed a well-nourished male with a three-inch oblique incision across the right upper rectus, at the middle of which there was a discharging sinus, the surrounding skin being irritated and reddened. Methylene blue given by mouth appeared at the sinus, one and one-half minutes after ingestion. X-ray examination unsatisfactory. After nine days in hospital, discharge practically disappeared, and operative interference was deemed inadvisable.

Case V.—S. W., female, aged thirty-eight. No. 61–136. Admitted June 5, 1916. Died August 6, 1916. Diagnosis: Empyema of gall-bladder. Cholelithiasis. 1. Operation: Cholecystectomy with drainage. Complications: Common duct obstruction. 2. Operation: Left hepato-duodenostomy. Complication: Duodenal fistula. 3. Operation: Gastro-enterostomy with pyloric occlusion.

History: One year ago, pain in the right hypochondrium radiating to back lasting two weeks. One month ago, second attack lasting for two hours. Last attack five weeks ago. Never jaundiced.

Physical examination was negative, except that liver is palpable one inch below the costal margin and the edges are sharp.

June 10, 1916, operation, cholecystectomy for empyema of gall-bladder. Right rectus incision; gall-bladder enlarged and adherent to surrounding structures. Adhesions freed, cystic vessels tied; gall-bladder amputated. Rather severe hemorrhage. Cystic and common duct palpated and found normal. Drainage, one tube to stump and one rubber dam down to lower surface of liver with packing. One day post-operative, slight jaundice. Five days post-operative, jaundice more marked; packing removed. Eleven days post-operative, jaundice intense, stools clay-colored. Twenty-three days post-operative, still discharging bile. Forty-one days post-operative, discharge of bile profuse from sinus. Forty-seven days post-operative, secondary operation. Hepato-duodenostomy for common duct obstruction. Incision through former scar. Adhesions divided, lower part of common duct

obliterated. Probe enters right and left hepatic duct easily. Persistent hemorrhage controlled with difficulty. Smallest calibre tube, two and one-half inches long, into left hepatic duct and inserted into small opening in duodenum and buried by sewing duodenum over it and suturing the duodenum to the under surface of the liver. Drainage: Rubber dam drain to Morrison's pouch. Eleven days post-operative, oozing from wound. Sixteen days post-operative, transfusion; duodenal fistula present. Murphy drip. Nineteen days post-operative, condition worse, retaining very little nourishment. Jaundice still deep. Twenty-one days post-operative, duodenal leakage profuse. Third operation, button gastro-enterostomy and pyloric occlusion and four Pagenstecher sutures. Died two hours later.

Case VI.—R. R., female, aged (?). No. 60–14. Admitted April 10, 1915. Discharged June 10, 1915. Diagnosis: Common duct obstruction; cholangitis. Operation: Choledochotomy, drainage. Complications: Chronic nephritis, duodenal fistula.

History: In 1909, patient had upper abdominal symptoms, and in 1914, was operated upon for cholelithiasis and acute cholecystitis; cholecystectomy being performed. For four months after this operation she was well. Three months ago she began to have epigastric pain referred to the small of her back without nausea or vomiting. Jaundiced for past four days, with some temperature. Physical examination was negative except for jaundice and scar of previous incision.

April 10, 1915, choledochotomy, drainage of common duct obstruction, cholangitis. Right rectus incision. Adhesions freed from stomach and colon and from liver bed. Common duct found dilated and distended with diameter of one and one-half inches. Tube passed into duodenum, and on withdrawal, a plug of mucus was removed. Tube sewed into common duct. Drainage tube and double packings. Five days post-operative, packings removed. Twenty-nine days post-operative, duodenal fistula evidenced by digestion of skin and tissues and the appearance of methylene blue from the sinus when given by mouth. Forty-three days post-operative, fistula healed. Fifty days post-operative, discharged as well.

Case VII.—S. D., aged thirty-seven. No. 61–74. Admitted August 7, 1914. Died August 16, 1914. Diagnosis: Acute gangrenous cholecystitis; cholelithiasis. Operation: Cholecystectomy. Duodenorrhaphy. Complications: Duodenal fistula. Secondary operation: Button gastrojejunostomy and pyloric occlusion.

History: For three weeks pain in the right hypochondrium radiating to shoulder. Four days ago became jaundiced; stools not clay-colored. Physical examination showed some rigidity in the right upper rectus. On deep palpation, a round, smooth mass in the region of the liver.

August 8, 1914, operation. Right rectus incision; cholecystectomy. Palpation of stone in retroduodenal part of common bile duct. Duodenotomy. Duodenorrhaphy by two layers of sutures, one of chromic and the second of Pagenstecher. Drainage, one rubber dam and three pieces of packing. Four days post-operative, a profuse, rusty-colored discharge with a foul odor. Six days post-operative, discharge definitely bile-tinged. Seven days post-operative, drainage brownish and foul smelling. Methylene blue by mouth evidenced in wound five minutes after ingestion. Secondary operation. Gastrojejunostomy by button with pyloric occlusion by four Pagenstecher sutures. Eight days post-operative, exitus.

Case VIII.—M. B., fifty-four years. No. 672. Admitted January 20, 1913. Died April 21, 1913. Diagnosis: Acute gangrenous cholecystitis, cholelithiasis, common duct obstruction. Operation: Cholecystectomy and common duct drainage. Complications: Common duct obstruction. Secondary operation: Secondary common duct drainage. Complications: Duodenal fistula. Third operation: Posterior gastro-enterostomy, button, with pyloric occlusion.

History: For two months, pain in right upper quadrant radiating to shoulder;

jaundiced for past ten days. Physical examination shows mass in upper abdomen, in region of liver, globular, size of cocoanut.

January 21, 1913, operation. Right rectus incision. Right lobe of liver enlarged four fingers below the costal margin. Gall-bladder thickened. Cholecystectomy. Choledochotomy. Drainage tube sutured into place and gauze to foramen of Winslow, cystic duct and liver bed. Fifteen days post-operative, stools clay-colored, appetite poor. Discharge of bile. Sixty days post-operative, stools still clay-colored. Eighty days post-operative, second operation. Choledochotomy and hepatic duct drainage for common duct obstruction. In separating the adhesions a hole was torn into the duodenum; through it the papilla was explored and dilated, but the probe was not able to pass through the common duct. A duodenorrhaphy was performed with two layers of chromic and Pagenstecher over it. The common duct was opened and a stone removed. A tube placed into the common up into the hepatic duct with iodoform packing above. Rubber dam down to intestinal sutures. Three days post-operative, profuse discharge of bile. Five days post-operative, skin edges rather excoriated. Six days post-operative, mucus discharge and bile from sinus. Methylene blue by mouth appears soon in wound. Seven days post-operative, patient going down hill so rapidly and leakage so profuse that through a left rectus incision, a posterior gastro-jejunostomy with button and pyloric occlusion with two reefing Pagenstecher sutures was done. The old tube in common duct was attached to bottle drainage and a rubber dam placed down to the duodenum to conduct any leakage to superficial dressings which were changed whenever necessary. Thirteen days post-operative, condition not good. Leakage still continued. Duodenal contents fed by mouth. Fifteen days post-operative, death.

An analysis of the 61 cases of external duodenal fistulæ abstracted in this paper showed 23 to have followed operations upon the gall-bladder, 14 duodenal ulcer, 10 nephrectomy, 6 resections of the stomach, 6 traumatic rupture of the duodenum, 1 carcinoma of the pancreas, and 1 intestinal tuberculosis. In the entire group there was a mortality of 51 per cent. Thirty-six were treated conservatively with a mortality of 47 per cent. Twenty-five were treated by operative procedures, with a mortality of 54 per cent.

Fourteen cases of fistulæ which followed simple operations upon the gall-bladder had a general mortality of 15 per cent. Ten of these were treated conservatively with no mortality; 4 were operated upon, 2 successfully.

In 11 cases in which the duodenum was opened either at the time of operation, intentionally or accidentally, or found ruptured from external trauma, there was a mortality of 64 per cent. Eight were operated upon with a mortality of 85 per cent., and the 3 treated conservatively recovered.

The 14 cases which occurred after perforated duodenal ulcer had a general mortality of 64 per cent. Of 9 treated conservatively 7 died, and of 5 treated by operation, 2 succumbed. Ten cases after right nephrectomy had a combined mortality of 40 per cent. Of 6 treated conservatively, 3 recovered. And of the 4 treated by operation, 1 died.

In the fistulæ following the Billroth operation the combined mortality

was 50 per cent. Four treated by conservative measures had a mortality of 50 per cent. One of the 2 cases operated upon died.

It is evident from these statistics that the prognosis is always grave, excepting those which follow gall-bladder operations in which the opening of the fistula is invariably small. These cases as a rule do well with conservative treatment. As far as the other cases are concerned, the general mortality is about 50 per cent., both after conservative and operative measures. The figures based on the conservative treatment can probably not be improved, but there is no doubt that the operative mortality can be definitely lowered. To accomplish this, surgical measures must be employed as soon as the fistula has formed and the proper operation must be employed. Simple suture except for retroperitoneal fistulæ must absolutely be abandoned. Gastro-enterostomy with pyloric occlusion with a general mortality of 85 per cent. offers very little hope. Jejunostomy at present has a mortality of about 45 per cent., and from all angles it certainly appears to be the operation of choice, especially if it is combined with the aspiration of the contents of the duodenal fistula.

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EXTENSIVE RESECTION OF THE SMALL INTESTINE

REPORT OF RECOVERY AFTER RESECTION OF FIFTEEN FEET OF SMALL INTESTINE AND HYSTERECTOMY

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Before reporting the case it may not be amiss to discuss certain facts which are of interest and pertain to such problems of resection, namely: 1. The length and function of the small intestine. 2. How much may be resected with safety and how is such loss compensated? 3. What is the proper surgical procedure in a given case and what is the post-operative treatment with special reference to nutrition?

The writer's authority for most of the facts as stated below is that of Rost.*

The length of the small intestine varies from 18 to 26 feet, the average being 19 feet. It is relatively shorter in women as compared to men and relatively longer in children. It is shorter in meat eaters as compared to vegetarians. Japs who are great consumers of rice have relatively longer intestines. For every 100 centimetres of body length there are 387 centimetres of small intestine and 91 centimetres of large intestine.

The small intestine secretes enterokinase which activates trypsin; erepsin which reduces albumoses and peptones to crystalline substances. It also secretes lipase, nuclease, and carbohydrate, splitting enzymes such as lactase. Water is quickly absorbed in the upper part of the small intestine. Carbohydrates are absorbed as monosaccharides, and fats when converted into soluble form as by fat splitting enzymes and bile. Absorption of food is practically completed in the small intestine. The jejunum absorbs more fluid and sugar, the ileum absorbs more proteids and fats. Food in noteworthy amounts will pass into the large intestine only in over-nutrition or catarrhal condition of mucosa, except such food containing detritus and cellulose which is split up by the bacteria in the colon and there absorbed. Consequently those having a fistula of the small intestine are best fed on concentrated food such as chopped meat, and other food free from cellulose.

The large intestine readily absorbs alcohol, about 20 per cent. of sugar and 50 per cent. of water; nutritive enemas containing the above are easily absorbed.

How much may be resected with safety and how is such loss compensated? The most extensive resections reported done successfully were those of V. Brenner, 540 centimetres; Gheden, 534 centimetres; Nigrisili, 520, and Axhausen, 475 centimetres, and Pouchet, 400 centimetres, the length of resection therefore ranging from 13 to 18 feet. These cases recovered from operation, but nearly all died shortly afterward. One-half of the small

* Rost's Surgical Pathological Physiology, published by Blakiston, 1923.

intestine may be removed without endangering life. The removal of 80 per cent. of intestine proves fatal. This proportion applies to animal and man alike.

The ileum is the part most often removed in extensive resection. Resection of jejunum is not much more dangerous than that of ileum. The digestive disturbances that immediately follow extensive resections of small intestine are diarrhœa, loss of weight, bulimia and thirst. The intestine remains sensitive for a long time afterward. Equilibrium is finally established. Compensation takes place in resection of the ileum in the following manner: There occurs an increased gastric secretion and the gastric digestion lasts two hours longer, and the intestinal movements in the jejunum, *i.e.*, above the place of resection, are slowed. Cleavage of chyme progresses further, with the result that twice as much is absorbed in the jejunum as shown by experiments on fistula dogs. It is thus shown that the stomach, duodenum and jejunum substitute for resected ileum. The colon takes no part in the compensatory process as proven by other experiments.

In resection of jejunum there is an increase in pancreatic secretion. The chyme is less digested than before operation and less proteids, carbohydrates and fats are absorbed in the small intestine. The colon compensates for such resection except that it cannot absorb much fat. In such resections carbohydrates are well utilized, proteids less and fat is utilized poorest of all.

The nutrition of patients in extensive resections of the intestine is best sustained by giving abundant amount of carbohydrates; food rich in nitrogen is best supplied by giving chopped meat, animal nitrogen being more easily assimilated than vegetable nitrogen. Diminish the intake of fat, for fat makes the action of digestive juices on proteids more difficult. What little fat is given is best given in the form that is most easily digested and absorbed, such being olive oil, goose fat, and lard. No anatomical change in the form of compensatory enlargement has been demonstrated that might be due to resection. The above facts are of special interest in consideration of the following case report:

CASE.—*Perforation of uterus by curette; prolapse of intestine through vagina; extensive tearing of mesentery; laparotomy excision of fifteen feet of small intestine, followed by removal of uterus; Recovery.*—M. A. Female, twenty-six years of age, married, private secretary, white, born in U. S. A. Last menstruation, January 15, 1923. March 29, two and a half months later, began spontaneously to have profuse vaginal bleeding, which continued for 5 days. April 4 consulted a physician, who on April 6 emptied the uterus with the resulting uterine perforation with prolapse of the intestine. Immediately following the incident the writer was called by the physician, who stated what had occurred. Patient was seen in consultation 15 minutes later and immediate removal to the United Israel-Zion Hospital was advised. Condition of patient appeared hopeless. Many loops of small intestine lay loosely wrapped in cotton, appearing as long as the ordinary jumping rope. Patient was fully conscious, looked very pale, pulse was 120 and irregular. The abdomen was tender, showing evidences of free fluid. Patient was immediately taken to operating room and prepared vaginally

and abdominally. The protruding intestine was cleansed with saline. Operation began 10 P.M. about one and one-half hours following the curettage. Operation completed 11 P.M., time being one hour.

Midabdominal subumbilical incision four inches long was made, and peritoneum incised. A large amount of free fresh blood was found in the peritoneal cavity. A perforation of the uterus about one inch long was found on the anterior uterine wall about one inch above the level of the internal os. About fifteen feet of intestine passed through this perforation. The mesentery of the small intestine was badly torn. There was profuse bleeding from its edges which were irregular, and had many loose tabs. The right broad ligament was badly torn, being the seat of a large hæmatoma. The peritoneal cavity was walled off as much as possible with lap sponges, and the accumulated blood removed. The intestine which was stripped of its mesentery was resected by applying a pair of intestinal clamps to either end of the loop, one end being close to the ileocæcal junction and the other at the lower portion of the jejunum. The loop of intestine was severed by means of cautery. Bleeding from the mesenteric vessels was controlled by sutures and ligatures, utilizing the same to approximate the torn edges up to one inch from the intestinal border. About 40 minutes were consumed in repairing the torn mesentery, conserving as much as possible the blood supply to the remaining intestine, which appeared rather dubious in places. An end-to-end anastomosis was done by an outer sero-muscular layer of continuous Lambert suture of 00 chromic and an inner continuous through-and-through Connell suture.

Because of the large uterine perforation and bleeding, and particularly because of the traumatized broad ligament, a hysterectomy was deemed advisable, which was done rather hurriedly, consuming for the intestinal anastomosis and hysterectomy and abdominal closure twenty minutes. Supravaginal hysterectomy was done in the usual manner by clamp and suture method, leaving in the tubes and ovaries. The cervical stump was cauterized and the raw surface of cervix and broad ligaments peritonealized. Enough of an opening was left at cervical stump, through which was inserted a strip of iodoform gauze into the vagina, draining the pelvis. Cigarette drains were inserted, one into the pelvis and another into the right iliac fossa directed away from the point of anastomosis. The abdominal cavity appeared quite empty because of the removal of almost all of the ileum and part of the jejunum as well as the uterus. During closure of abdominal cavity patient was reacting and straining, but none of its contents protruded from the incision for the above reason.

The abdominal wall was sutured in layers, the peritoneum with a continuous suture of catgut, the fascia with chromic, and skin and fascia with silkworm figure of 8 interrupted, and the skin with silk suture. The abdomen on closure appeared markedly scaphoid, more so on the right side, requiring a good deal of gauze dressings to fill in the concavity, in order to properly apply the adhesive straps.

Condition During Operation.—Anæsthetic: gas, oxygen, with very little ether. Pulse 120 at start, 160 thirty-five minutes later and 120 at the end of the operation after 1500 c.c. of saline were given intravenously.

Pathological Report.—Uterus without adnexa is the size of a fist. The wall is 1 inch in thickness. The inner surface of the uterus appears freshly scraped, a ragged perforation on the anterior wall admits one finger. Intestine measured by means of tape measure is fifteen feet long. It appears to be the small intestine stripped of its mesentery completely, except at either end where about one-half inch of mesentery in width is attached to intestine.

Microscopically, section of the uterus shows the usual findings of pregnancy.

Post-operative Course.—Condition after operation fair. Temperature 99, pulse 120, slowing down to 100 in a few hours. Patient was placed in Fowler's

position, continuous Murphy drip of 2 per cent. glucose and sodium bicarbonate given.

April 7, first day after operation, pulse rose to 130, temperature 102. No vomiting, pain in lower abdomen, some blood-stained vaginal discharge. Voided spontaneously 12 ounces in first 24 hours.

April 8, 2nd day, pulse 130, is weak and irregular at times, temperature 100–101, respirations 30–35, voided 46 ounces. Marked epigastric distress and pain. During stomach lavage about one quart of dark bile stained fluid returned. Patient experienced relief after lavage, which was done 3 to 4 times daily for first week, obtaining the same return after each lavage and followed by great relief of epigastric burning and distress. Patient would beg for such stomach lavage, anticipating the relief that followed. Continuous hypodermoclysis was given for the first two days and then was given twice daily, absorbing for one week 2000–3000 c.c. of normal saline in 24 hours. Harris drip of 2 per cent. glucose and sodium bicarbonate was given at intervals, absorbing about 1000 c.c. in 24 hours.

A soapsuds enema was given followed by good results, returning dark colored fluid, containing fecal matter and some flatus.

April 9, temperature 99–101, pulse 130. Enema given with effectual result, dark brown formed stool of moderate amount. Was given small quantities of water and ice by mouth with no vomiting. Vaginal gauze drain removed. Spontaneous bowel movement.

April 10 and 11, complains of dryness of throat and thirst and severe abdominal pain. Dressing was saturated with serous fluid. Had good bowel movements with and without the aid of an enema, expelling a good deal of flatus. Voids 40–50 ounces daily.

April 12, 6th day post-operative, required 1/6 of morphin for abdominal pain. Felt greatly relieved after the escape of large amount of seropurulent discharge through vagina. Retentive enema of normal saline given in place of Harris drip. Abdominal drains removed, wound appears red and inflamed. Was given hot tea and water by mouth.

April 13, temperature 103, pulse 140, seemed quite emaciated, appears drowsy, has marked epigastric distress. Was given nutritive enema every 3 hours, containing sherry wine ℥i peptonized milk ℥iii and liquid peptonoids ℥ii.

April 14, condition improved, pulse 120, temperature 101. The nourishment was given by mouth instead of by rectum. Complained of marked diarrhœa, 10 bowel movements in 24 hours. Profuse purulent discharge from abdominal wound and vagina.

April 15, condition much improved, pulse 110, temperature 100, retains fluids well, no epigastric distress, diarrhœa stopped, having only two movements in 24 hours, voiding plenty. Hypodermoclysis and enemas discontinued. Appears to have lost about 25 to 30 pounds, as evidenced by flabby skin, etc., as compared to time of operation.

April 16, condition same, increasing diet, adding eggnogs, zwieback, and strained gruel.

April 18, condition good, temperature 99, pulse 110, diet increased, adding ice cream, fruit juices, chicken soup. Profuse discharge of pus from wound. No vaginal discharge. A slough, size of pigeon's egg, was removed from the depths of wound, being probably some mesenteric slough. Sutures removed. Suppurating wound is about two inches in length and is almost of same depth; holds 3 to 4 ounces of Dakin's solution with which the wound was irrigated daily for about 8 days.

April 20, discharge is much less after the separation of slough and irrigation with Dakin's solution. Soft diet, adding lamb chops, chicken, and many sweets.

April 20–30, condition improving daily, temperature striking normal, pulse 100, daily normal bowel movements. Wound appears healthy, granulating, being half of its original size.

May 2, 26th day after operation, patient began to complain of sudden severe abdominal pain; marked visible persistalsis was noticed in left upper abdomen. Loops of intestine could be observed moving slowly toward right up to region of umbilicus, at which time pain was excruciating. Left side of abdomen became markedly distended. Felt nauseated all day. Vomited for the first time since operation; vomitus consisted of undigested food; vomited a few times during the day and the following night. Abdominal pain continued, requiring sedatives. Appeared to suffer from beginning intestinal obstruction probably due to some adhesions forming. Pulse 140, poor quality.

May 3, felt greatly relieved toward noon with the sudden escape of gas and discharge from abdominal wound. On changing of dressing a fecal discharge, simulating chyme, and an escape of gas from upper angle of wound was observed. Evidently a spontaneous enterostomy had occurred with relief of the intestinal obstruction. The seat of the opening was probably in the part of small intestine near the point of anastomsis, or at a place where the blood supply appeared rather questionable at time of operation.

May 4, condition fair. Pulse 140, temperature 100. Profuse fecal discharge from wound having the appearance of mustard. Had two spontaneous bowel movements.

May 5, discharge unchanged. Skin over abdomen red and much irritated from the intestinal discharge. Complains of severe burning of skin; appears very uncomfortable. Skin protected by zinc oxide ointment and frequent change of dressing.

May 6–7, continued to have slight gas pains, which were relieved by the escape of gas and intestinal contents from wound.

May 8–26, condition steadily improving, temperature ranging from 98–99, pulse 100. Has ravenous appetite. Is out of bed in a chair on May 26. Appears as if she gained about 10 or 15 pounds in the past three weeks. Weighs now 105 pounds. An opening about the size of the head of a pin at the upper angle of wound appears to communicate with the intestine.

June 1, the granulating wound is the size of a nickel. There is very slight discharge during the 24 hours. It is of a yellowish color and is odorless. The patient is walking around without discomfort. Daily bowel movements without enema. Marked bulimia, cannot get enough to eat. Eats at frequent intervals, regular diet, drinks two quarts of milk daily, consumes a good deal of ice cream and sweets.

June 7, Patient feels fine; gained two pounds since May 26.

A photograph taken of patient compares favorably with the one she took a short time before operation. Apparently patient is thriving well, getting along with the little intestine she possesses. Abdomen is full, not scaphoid, has a thick layer of adipose tissue. She takes part in making dressings and nursing some of the other patients. Appears perfectly normal and is ready to be discharged.

June 11, intestinal fistula completely closed, abdominal wound healed, except for a slight granulation size of a finger nail. Appetite undiminished, has two bowel movements daily instead of being constipated as before operation.

This case presents the following interesting facts:

1. The extent of the extraordinary damage that was inflicted during the curettage.

2. Quick action was imperative, because of the danger of hemorrhage and infection owing to the nature of the injuries sustained. Because of the extensive trauma and the necessary repair, speedy action was essential in this case, so as to spare her the slim chance of recovery that she might have.

3. Resection of such large amount, fifteen feet of small intestine, being in her case most likely more than 75 per cent. of its entire length, was not a matter of choice but of dire necessity. Likewise hysterectomy seemed advisable, because of the large perforation of uterus and trauma of broad ligament.

4. The post-operative course and treatment. The intravenous of saline 1500 c.c., repeated hypodermoclysis, and proctoclysis continued for ten days tided her through a critical period. Very little absorption took place in the gastro-intestinal tract during this period, as evidenced by gastric dilatation and retention of bilious fluid which required repeated gastric lavage. Such lavage relieved her a great deal and materially helped by comforting patient and eliminating the toxic material accumulated in stomach.

5. No evidence of obstruction appeared until the twenty-sixth day after operation, as proven by the daily bowel movements. The obstruction that then occurred was most likely due to post-operative adhesions.

6. The safety valve, the fecal fistula that then appeared, was most likely at a weakened part of small intestine, near point of anastomosis or at some other portion of the small intestine, where its blood supply was impaired because of the traumatized mesentery. The anastomosis was evidently satisfactory, otherwise there would have developed a fecal fistula much sooner.

7. That the nutrition of patient is well maintained is evidenced by the gain in weight and comfort of patient, which is made possible by feeding at frequent intervals with concentrated food, using a good deal of carbohydrates and proteids, and very little of food containing cellulose or fat.

8. The patient presented the typical symptoms credited to such extensive resections, namely, thirst, bulimia, diarrhœa and loss of weight, and sensitive intestines, all of which have occurred during her first few weeks of her illness. The patient now has established a compensatory equilibrium along the lines described in the resumé of literature.

9. The writer considered it a duty and privilege to report the recovery of this rare case. He could not find in the literature a case of a similar nature, one where resection of fifteen feet of small intestine with hysterectomy, complicated by partial intestinal obstruction and fecal fistula, resulted in recovery.

THE RELATION OF CIRRHOSIS OF MESENTERY AND SUBPERITONEAL LIPOMATOSIS TO ALCOHOL AND WORK

By Sir John O'Conor, M.D.
of Buenos Aires, Argentina

In the Lancet, June 3, 1916, under the first heading I called attention to some peculiar conditions which I had met with in the abdomens of some fatty and alcoholic subjects.

1. *Cirrhosis of the great omentum* with marked induration which at first sight suggested malignant infiltration, but the history, general condition, absence of any suspect primary focus, with coexistence of a visible cirrhotic liver, dispelled with a suspicion, and subsequent microscopic examination of excised specimens demonstrating solely fibrous tissue formation dictated the conclusion that as in hepatic cirrhosis a similar obvious condition may from the same cause occur in the great omentum.

2. *Induration of Bowel Wall and Friability of Adhesions.*—In confirmed alcoholics with or without obesity I have often observed on tying peritoneal adhesions that the ligature tore through in an unexpected manner and often found this accentuated when ligating the meso-appendix. From time to time I have also noted (independent of infection) a cirrhotic condition (dry thickening) of the intestinal walls, particularly marked in cæcum and descending colon, in which on the introduction of sutures there was an unusual tendency for the needle to break through or for the stitches to cut out as they were being knotted.

3. *Indurated Pericolitis.*—Palpable chronic inflammatory thickening of the mesocolon along its line of attachment to the gut, frequently associated with adhesions and evident contraction of the adjoining appendices epiploicæ. These patients always belong to the bibulous class and invariably give an indefinite history of gastro-intestinal torment coupled with subjective symptoms, *e.g.*, the morning mouth, feeling like nothing until resuscitated by the matutinal gin and *tonic!* vague spasmodic pains with general abdominal discomfort and black excrement, a continuous itis from lips to anus.

I have proved to my own satisfaction that surgery (separation of adhesions) in such cases is an absolute futile procedure.

In a few instances in which the above syndrome was definite the presence of sugar in the urine suggested the probability of similar cirrhosis of pancreatic fat interfering with the functions of the islands of Langerhans.

These forms of cirrhosis I attribute to microbic infection passing from within outwards through the bowel wall, the result of prolonged irritation of the mucous coat from constant saturation with surplus alcohol.

While I miss no opportunity to arraign the abuse of alcohol—abusus non

tollit usum—I wish it to be clearly understood that decades of medical and personal experience have convinced me that as a necessary brake and nerve food in the hurry and scurry of modern urban life there is a necessary self-determinable alcoholic coefficient in the metabolic equation of every rational human adult, and that the most likely victims for microbic attack, cancer and the asylum are ascetic abstainers and suicidal topers.

Quite recently I had a further opportunity for demonstrating a well marked instance of cirrhosis of the great omentum in a man aged fifty-one on whom I was operating (assisted by my colleague, Dr. S. Almond) for appendicitis and in whom there was a positive history of steady indulgence in whisky for many years. The lower portion of the great omentum presented a contracted red appearance, its free margin was obviously thickened and when grasped between the fingers felt like a large fold of hard fibrous tissue. There was nothing further to note beyond an unusually fatty condition of the meso-appendix and an excess of properitoneal and parietal fat. As the liver was out of range of inspection, its appearance could not be noted, but on palpation its lower border did not lack in consistency.

By peculiar coincidence a few days later I met by accident the most supreme case of cirrhosis of the omentum which I have ever seen, combined with considerable pericolic induration, and in which for some moments it was found difficult to exclude general peritoneal cancer; the patient was a campman, and when I saw him a few months ago—twelve years after operation—he was looking the emblem of health with a complexion that would do credit to a rose garden.

Puzzle though it may be to science both of these gentlemen went through operation (appendectomy) without turning a hair, and convalescence followed, without a move in temperature or pulse. I have frequently observed that the sturdy (not putty) type of Anglo-Saxon of full habit of body who takes regular outdoor exercise of a strenuous kind and who never fails to make same the excuse for some extra rounds of whiskies (plus a few gins by way of antidote) stands operation extraordinarily well. In the chloroform days I more than once heard my veteran chloroformist exclaim, as a prelude to some tongue dragging or artificial respiration, " These damn teetotallers always let me down;" his absolute bête noire was the worn-to-the-woof " dry " athlete.

4. *Fat Blocked Abdomens.*—In obese females, apart from the common parietal form of Dercum's disease which if undetected may readily lead to an erroneous intra-abdominal diagnosis, my power of perception has been frequently extended to explain, much less treat, the cause of ill-defined spasmodic pains of a dragging or colicky nature commonly emphasized in the left abdomen in which detail revision failed to find any organic lesion, not even a suspicion of varicocele of left annexa.

After the whole litany of science has become exhausted one empirically prescribes a modified dietary and some daily lubricant, the patient seems temporarily to experience relief but sooner or later returns with " I am as bad as ever." Another gruelling examination ensues, including X-rays of

everything abdominal, the hands and eyes are made to scrutinize every fold and crevice, all the secretions, excepting endocrinic are duly tested, result nil, mutual hopeless dissatisfaction ensues which, by the way, only just provides one chink for salvation—exploratory operation.

On opening the abdomen inches of parietal fat discomfit the operator, properitoneal adipose deposits then loom into perspective, bulging cushions of retroperitoneal blubber next obfuscate the vista, at last, when internal palpation commences, anvils of fat, huge appendices epiploicæ, keep continually bobbing up and getting in one's way. By the time a negative assize has been concluded one begins to feel partial-like to those who on extreme occasion fortify themselves with a stiff whisky and soda before tackling the superproblem, how on earth to close the gap in such a drum. I confess that I have often been redeemed by interrupted through-and-through sutures of silk rope introduced by a crowbar of a Doyen needle.

Apart from the superficial tenderness invariably hyper-complained of when one handles the impossible belly of the corpulent female, the size of some of these epiploic tufts suggests that the dragging of such weights on the bowel wall may cause discomfort, particularly when the colon becomes ballooned with fæces and gas. On two occasions I was tempted to undertake excision of these appendages, but found the job so irksome the more I remove the more seemed to spring up that in each I eventually laid down tools.

It seems a strange paradox that ladies who if their pet dog does not get his morning run or favorite horse his gallop raise an awful dust, yet remain so hypnotized in the snobbery of their trans-rhesian ascent as not to have the gumption to apply similar stimulation to their own big gut. In nature there is no greater comedy than to behold an image in wax or a unit of fat leading her Anubis by a string up and down the pavement in front of her hall door until he relieves himself while she with envious glances pines for some dynamite pill, petroleum well, or the next world to achieve the same object.

The man or woman who does not regularly experience the exhilarating sensation derived from outdoor work or exercise robs himself or herself of one of the two pleasures which to the ordinary mortal make this life livable.

The treatment which I now adopt and find most applicable for such bodies is a rigid daily dietary for one to three months of two litres of milk, tea or coffee, two eggs, some green vegetables and fruit with a teaspoonful of sulphate of soda in a claret glass of hot water in the early morning. For ladies in the prime a special dispensation is granted—once a week—in order that they may do justice to the traditional functions inspired by the legend of *Saturday night.*

If an adipose condition has existed from birth or is hereditary, I prescribe a tablet of one grain of thyroid extract to be taken with each meal.

Afterwards when some stones of fat have been consumed the patient is placed on a permanent diet in which fat carbohydrates and alcohol are reduced to a combustible limit; this is supplemented by what is to many of these people

a new regime, *viz.*, a regular system of morning housework, including—what is an excellent preventive of excessive embonpoint—polishing and scrubbing floors, followed by a brisk walk to the market and grocer's before the midday meal. After the morning floors are off I enjoin physical culture in the open air, weeding, hoeing and raking the garden.

The moral, the only way to keep an old horse from getting stiff is to keep him working, applies with equal if not greater force to the human being.

I have seen numerous instances of active men retire from work in this country in the plenitude of their business energy with a fortune or pension sufficient to live "at ease" at home. The majority found "*rest*" within five years.

I am convinced that a human machine in full activity which has for years been geared up to the strain of certain conditions if indefinitely thrown out of action has a strong tendency "to cease to exist;" in other words, the body collapses with the mind which is the spark plug of the concern.

INTESTINAL OBSTRUCTION*

AN EXPERIMENTAL STUDY OF THE THERAPEUTIC VALUE OF THE ADMINISTRATION OF SODIUM CHLORIDE

By Glover H. Copher, M.D.
and
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Haden and Orr[1] have recently published an experimental study of intestinal obstruction, from which study these investigators reached the conclusion that there was definite relationship between the intoxication and the sodium chloride content of the blood. These investigators are furthermore of the opinion that the administration of sodium chloride serves to prevent intoxication on account of its property to react with the toxic substance and destroy its toxicity.

The experiments of Whipple[2] *et al.*, have shown that in the intoxication of intestinal obstruction there is marked rise of the non-coagulable nitrogen of the blood. Haden and Orr confirmed this finding and observed that there was a coincident fall in the blood chlorides. They show furthermore that the marked rise in non-coagulable nitrogen can be prevented by the administration of sodium chloride in sufficient quantities to prevent the fall in chlorides of the blood. They conjecture that the rise in NPN is due to protein destruction by the action of the toxic substance and that the fact that administration of chlorides prevents the increase in NPN is evidence that the toxin is neutralized by the sodium chloride. The supposed reaction which takes place is stated by them to be: $X + NaCl + H_2CO_3 = XHCl + NaHCO_3$. In this reaction the toxin is represented by X. Further evidence of this reaction was their observation that the CO_2 combining power of the blood rose with the depletion of the chlorides. From their experiments the authors conclude that administration of chlorides has definite curative value in the treatment of intestinal obstruction.

A careful analysis of these experiments shows that the blood findings observed by the authors were more noticeable in high intestinal obstruction and most marked in pyloric obstruction. It would seem, therefore, that these investigators might be confusing "intestinal obstruction" and "pyloric obstruction." For the purpose of clearing up this point the following experiments were carried out:

Dogs were used as experimental animals. All operations were done under complete surgical anæsthesia. Every effort was made to prevent pain and suffering of the animals. Animals not dying as a result of the experi-

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mental procedure were sacrificed by administration of chloroform. Only one experiment of each group will be described. The experiments were repeated often enough to convince us of the constancy of the findings noted.

Experiment No. 1, May 25, 1923.—Dog anæsthetized with ether. Abdomen opened. Jejunum sectioned near proximal end. Distal stump inverted. Ileum sectioned approximately 60 cm. distal to previous section of jejunum. The proximal stump inverted. The distal stump was united by end-to-end suture to the proximal stump of the sectioned jejunum. Abdomen closed.

This operative procedure resulted in an isolation and obstruction of 60 cm. of the small intestine. The continuity of the intestinal tract was reëstablished. The animal was fed on a diet of table scraps.

June 5.—After operation the animal promptly recovered from the effects of the operative procedure and showed very little evidence of intoxication until 10 days after operation, at which time the animal was very drowsy and failed to eat. On the 11th post-operative day the animal was clearly quite sick. A specimen of blood was taken, and the blood chlorides and non-protein nitrogen were determined. Blood chlorides 418 mg. per 100 c.c. NPN 40 mg. per 100 c.c.

June 8.—Animal died. Autopsy showed slight increase in free fluid in peritoneum. No peritonitis. The isolated loop was not perforated. It was distended. The loop contained approximately 500 c.c. of a thin foul smelling material. A large amount of previous experimental work by one of us has demonstrated that this fluid is so extremely toxic that ½ to 5 c.c. will kill a dog in 3 to 5 hours if given intravenously or intraperitoneally.

This experiment demonstrates that an obstruction of a loop of intestine without obstruction of the duodenum may exist for a period of eleven days and develop marked manifestations of toxæmia and accumulate within the lumen of the obstructed bowel a large amount of very toxic substance without there being any appreciable decrease in the blood chlorides or increase in the blood non-protein nitrogen.

Experiment No. 2, April 28, 1923.—Dog anæsthetized with ether. Abdomen opened. Isolation obstruction of a loop of jejunum and ileum 85 cm. long. Reëstablishment of continuity of intestinal tract as in experiment No. 1.

May 10.—Thirteen days after operation, animal moribund, sacrificed. No peritonitis. Isolated obstructed loop distended with 1450 c.c. of a thin foul smelling fluid.

Ten experiments were carried for determining the minimal lethal dose of this toxic fluid if it were given intravenously to normal dogs. In four experiments it was found that ½ c.c. of the toxic fluid per kilo of body weight of the animal injected was fatal in 3 to 5 hours.

This experiment was for the purpose of obtaining the toxic contents of an obstructed loop of intestine and determining the minimal lethal dose of this toxic fluid. The following experiments were all carried out with this standardized toxic fluid.

Experiment No. 3, May 14, 1923.—Dog weighing 6.6 K., blood chlorides 501 mg. per 100 c.c., anæsthetized. The external jugular vein was exposed. Three c.c. of the standard toxic fluid injected into the jugular vein.

Four-fifty P.M. Two and one half hours after injection. Animal vomiting.

Fluid stools. Typical picture of intense intoxication. Specimen of blood taken. Blood chlorides 500 mg. per 100 c.c.

Five P.M. Animal died. Autopsy showed intense hemorrhagic enteritis of duodenum and jejunum.

This experiment shows that an animal may die from the effects of the intravenous injection of the minimal lethal dose of the contents of an obstructed loop of intestine without any decrease in the blood chlorides.

Experiment No. 4, May 12, 1923.—Dog, wt. 4.5 K. Intravenous injection of a mixture of 2 c.c. of standard toxic loop content and 5 c.c. of a saturated aqueous solution of sodium chloride. The animal developed all the manifestations of severe intoxication and died four hours after injection. Autopsy showed intense hemorrhagic enteritis of the duodenum and jejunum.

This experiment shows that the toxic properties of the content of an obstructed loop of intestine are not decreased by the addition of sodium chloride.

Experiment No. 5, May 13, 1923.—Dog, wt. 15 K. Anæsthetized with ether. At 7:30 P.M. administration of normal saline solution was begun. The solution was given subcutaneously, intraperitoneally, and intravenously. Immediately after the administration of the normal sodium chloride was started the animal received 5 c.c. of the standard toxic loop content. The normal saline solution was continuously given. The animal developed the typical manifestations of acute intoxication and died 3 hours and 20 minutes after the injection of the toxic loop content. During the period elapsing between the injection of the toxic loop content the animal received 3000 c.c. of normal sodium chloride solution. Autopsy showed the characteristic pathologic lesions.

This experiment shows that there is no appreciable curative value of the administration of large quantities of sodium chloride solution in the intoxication which follows intravenous injection of the toxic content of an obstructed loop of intestine.

Discussion.—Intestinal obstruction is a condition in which the outcome is so often fatal that surgeons are ready to try any method which offers a possibility of relief. In perhaps no other surgical condition are there more available experimental methods to test the value of any method suggested. The experimental work of Murphy and Vincent,[3] Whipple, Stone and Bernheim,[4] Murphy and Brooks,[5] Dragstedt, Moorehead and Burcky,[6] and others, have established fundamental principles which make it possible to test the value of any curative method suggested. Furthermore, these principles already established are such that the possibility of a method for the relief of that intoxication which has already been established is remote.

The cause of the symptoms and death from mechanical obstruction of the intestine is the formation in the obstructed intestine of a powerfully toxic substance and the subsequent absorption of this toxic substance into the circulation. There are two independent processes concerned, the production of the toxin and the absorption of the toxin. For the intoxication it is obvious that both of these processes must operate.

It is not the purpose of this paper to discuss the controversy which has

arisen as to the manner of the production of the toxin. Whipple [7] has believed it to arise as a perversion of secretion of the mucous membrane. Murphy and Brooks [8] believed it to be due to the splitting of proteins by unusual bacterial activity. It suffices to state here that mechanical obstruction of the lumen of the intestine always leads to the formation in the lumen of the obstructed gut of a powerfully toxic material which is not present in the lumen of normal bowel. It is obvious, therefore, that any curative method as it concerns the production of the toxin must accomplish a relief of the obstruction.

As regards the absorption of the toxin, there are two independent factors to be considered, the prevention of further absorption of the toxin and the possibility of neutralizing the effects of that which has already been absorbed.

The most fundamental fact concerning the process of actual absorption of the toxin into the circulation is that established by Hartwell and Hoguet,[8] and Murphy and Brooks, who have shown that it is not absorbed by a normal mucosa and that any process which damages the mucosa leads to the absorption of the toxic loop content. The process most often concerned in promoting absorption of the toxin is the interference with blood supply of the obstructed loop of gut by strangulation or distention. It was pointed out by Brooks [9] that an experimental intestinal obstruction could be produced in which an animal would live for as much as 21 days with as much as 800 times the lethal dose of toxin in the obstructed loop if strangulation or marked distention did not occur. Any curative method, therefore, which has as its object the prevention of further absorption of the toxin, must be one which removes the toxic substance from the obstructed intestine, removes the intestine with the damaged mucosa, or institutes measures which would make the toxin innocuous if absorbed. To get the toxic substance out of a loop of obstructed gut is impossible. If a loop contained 1000 c.c. and 990 c.c. were removed the remaining 10 c.c. would undoubtedly be a lethal dose. Experimentally a loop of intestine cannot be washed free of toxin; the potency of the toxin is so great that many times the lethal dose may be entangled in the depths of the intestinal glands. This fact probably accounts for the conclusion of Whipple that the toxin arises in the cells of the mucosa. The removal of damaged mucosa in intestinal obstruction is imperative if this damage has been sufficiently great, as in a strangulated hernia with gangrenous bowel. The institution of measures which would render the toxin absorbed innocuous is the principle under investigation in this study.

There are certain facts which have been established by experiment which make it improbable that the toxin can be neutralized after it has entered the circulation. Whipple has shown that the toxin rapidly disappears from the blood stream after intravenous injection. Although the toxin has not been recovered from any of the body tissues, there is experimental evidence that the toxin is rapidly fixed by the body tissues. Werelius [10] believes that death in high intestinal obstruction is due to liver insufficiency. It would seem therefore that after absorption the toxin reacts with some body tissue and

irreparable damage is done, and that after a certain dose has been absorbed no possibility of relief of the intoxication is possible.

The only hope therefore of establishing a method for neutralization of the toxin absorbed from an obstructed loop of intestine is that this method must introduce some factor in the circulation which will react with the toxin to destroy it before it reaches the tissue. The use of sodium chloride as proposed by Haden and Orr was believed by them to be such a method. The experiments described in this paper do not confirm this belief.

The explanation of the different conclusions reached in this paper and those of Haden and Orr is probably due to a difference in the experimental methods employed. The experiments described in this paper were carried out in such a manner that the study was limited to the intoxication of intestinal obstruction without pyloric obstruction. We believe these should be considered independent processes, although clinically obstruction of the intestine must of necessity be more or less complicated by pyloric obstruction, accordingly as the site of obstruction of the intestine is high or low. Obstruction of the jejunum obviously produces greater and more rapidly developing stasis in the duodenum and, therefore, pyloric obstruction, than obstruction of the terminal ileum.

Further evidence that the reduction of blood chlorides is the result of pyloric obstruction has been obtained by Claussen of the St. Louis Children's Hospital from the determination of the blood chlorides in four cases of congenital pyloric stenosis. It has been found that these cases showed a marked reduction of blood chlorides. Further evidence that blood chlorides are not always reduced in intestinal obstruction was obtained in a case of complete obstruction of the terminal ileum which had existed for forty-eight hours and in which there was marked manifestation of intoxication. In this instance the blood chlorides were normal.

The clinical importance of these experiments is the same as that of all previous experimental studies. It shows that the primary object to be sought in the treatment of intestinal obstruction is early recognition of the condition and immediate institution of surgical treatment. If this treatment can be instituted before the patient has absorbed a lethal dose and it is possible to prevent further production or absorption of the toxin, the patient's life will be saved. If the lethal dose of toxin has already passed into the circulation, there is as yet no known method of cure.

CONCLUSIONS

1. Experimental animals may live for as much as two weeks with closed isolated loops of intestine.

2. These closed loops contain large quantities of toxic fluid, sometimes several hundred times enough toxin to kill a dog of equal weight.

3. Intravenous injection of this toxin causes death in healthy dogs in a few hours.

4. Death may occur without any decrease in the blood chlorides.

5. Administration of NaCl in large quantities does not influence the manifestations of intoxication after intravenous injection of toxin.

6. The factors which influence absorption of toxin are of much greater importance in the cure of intestinal obstruction than the factors of production of toxin. When a patient has gotten a certain dose in the circulation, there is no known method by which the damage done can be alleviated.

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MALIGNANT TUMORS OF THE TESTICLE IN CHILDREN*

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Pathological Report by Wm. A. Perkins, M. D., San Francisco, Calif.

The comparative rarity of malignant tumors of the testicle in children and the extent and size of the metastases found in a recent case prompt the following report:

E. C., a boy of ten years, entered the hospital with the complaint: (1) pain in the left side of the chest; (2) cough; (3) malaise and weakness. The family history was negative except that the maternal grandfather had died of "heart trouble," and the maternal great grandmother had died of uterine carcinoma. In the past history we find that the patient was a full term normal baby and had a normal development. He had measles at the age of 6 years, influenza at the age of 7 years (a light attack) and mumps and smallpox 1 year before entry. Under accidents and operations it is noted that the patient had a tonsillectomy one and one-half years prior to entry; also that about six months ago he was struck in the scrotum with a rock at which time the mother states that a tumor was found in the left side of the scrotum; she does not know, however, whether the tumor might not have been present prior to the accident. This tumor grew slowly in size and finally was operated on 5 months before entry. The mother states that she does not know what was found at operation but thinks that it was a hard solid tumor of the left testicle.† Two or three weeks ago the parents noted that a hard nodule had recurred at the site of the operation.

The present illness, according to the parents, began 5 weeks prior to entry, at which time the mother says the patient "caught a cold" and developed a fever, cough, dyspnœa and malaise. There was no expectoration or pain in the chest. It was found that the patient rested most comfortably when he lay or slept on the left side. The fever and cough disappeared in three days and the patient became well enough to return to school. He continued, however, to have a more or less tired feeling and a little dyspnœa, especially on exertion. These symptoms gradually increased until it was noticed that he was unable to play with other children and finally had difficulty even in getting about. A few days before entry the condition became so severe that he was taken to a physican, who made a diagnosis of fluid in the chest and referred the patient to the University Clinic. For a day prior to entry the patient had had to remain in bed because of dyspnœa and weakness. For a few days prior to entry he had had considerable pain in the left chest, especially posteriorly, from which some relief could be obtained by lying on the left side. The mother says that the patient has been losing weight but does not know how much.

Physical examination showed a markedly anæmic and emaciated boy of ten years, lying in bed on his left side, dyspnœic, using all accessory muscles of respiration, and with an anxious expression on his face. The superficial lymph-

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†Attempts to communicate with the surgeon who performed operation were unsuccessful, so that it is not known what was found at operation.

nodes were negative. Eyes, ears, nose and mouth were negative. The chest was quite asymmetrical, bulging on the left side and somewhat flattened on the right. There was some retraction of the right supra- and infra-clavicular fossæ and the left supra-clavicular fossa. The inter-costal spaces on the left were slightly bulging. There was no movement of the left chest with respiration either anteriorly or posteriorly. The right side was somewhat hypermobile. The thorax in general showed marked emaciation. *Lungs,* there was flatness over the entire left chest both anteriorly and posteriorly. This extended to just beyond the right border of the sternum while below it was continuous with dulness beneath both costal margins. Over this area there was absence of breath sounds, tactile fremitus, whispered voice, etc. On the right side there was an area of dulness which extended to just beyond the right nipple line, probably the area of cardiac dulness. The remainder of the right side anteriorly and posteriorly was hyper-resonant. An occasional crepitant râle could be heard at the left top, both anteriorly and posteriorly. D'Espine's sign was positive down to the eighth dorsal vertebra; Grocco's triangle was percussed in the lower right back. Heart showed an outline of cardiac dulness as noted above. Pulsations were seen in the 3rd, 4th, 5th, and 6th right interspaces. The sounds were regular and of good quality. No murmurs were heard. The blood-pressure was 95/60. Abdomen upon entry was level and symmetrical, but somewhat rigid. Abdominal respiration was marked. There was an area of dulness and tenderness across the upper abdomen. The liver was easily felt; it was firm and tender. The spleen was not definitely palpable. The kidneys were not felt. The abdominal examination was not satisfactory because of the rigidity. *Genitalia,* the right testis was partially descended. The left scrotum showed the scar of the previous operation. Buried in the scar could be felt a small firm nodule. No epididymis or vas was felt on this side. The remainder of the physical examination was irrelevant.

Course.—The left chest was tapped and 750 c.c. of hemorrhagic fluid removed. The patient felt much better; his dyspnœa seemed somewhat less. The following day 400 c.c. more of the hemorrhagic fluid were removed. These two tappings seemed to relieve the abdominal spasticity making palpation easier. A large firm tumor could now be felt occupying practically the entire left flank and extending up under the left costal margin. It was rather firmly fixed and did not move with respiration. Extending down from under the costal margin and lying upon this mass was the spleen which was now palpable. The patient continued to go down hill; the dyspnœa became worse in spite of repeated tappings. Each tapping always yielded from 350 to 400 c.c. of bloody fluid. The dyspnœa became so severe that the patient had to be kept under the influence of opiates. The respirations varied between 30 and 40 per minute. The patient died fifteen days after entry.

Laboratory data: Blood: Hæmoglobin, 80 per cent. (acid hæmatine); red blood cells 4,990,000; white blood cells, 19,000. Differential-neutrophiles, 50 per cent.; small mononuclears, 40 per cent.; large mononuclears and transitionals, 10 per cent.

Urine: Amber; acid; 1.020; albumin, faintest possible trace; sugar none; microscopic, red blood cells, none; white blood cells, occasional; epithelial cells, occasional; casts, occasional, finely granular.

Stool: Negative.

Von Pirquet: (Bovine and human) negative.

Nose and Throat Cultures: Staphylococcus albus, diphtheroids, micrococcus, catarrhalis.

Blood Wassermann: Negative with two antigens.

Pleural Fluid: Markedly hemorrhagic with the formation of fibrin shreds on standing; specific gravity—1.018; cell count: Red blood cells, 176,000; hæmoglobin, 10 per cent., (acid hematine); white blood cells, 2,400; differential-neutrophiles,

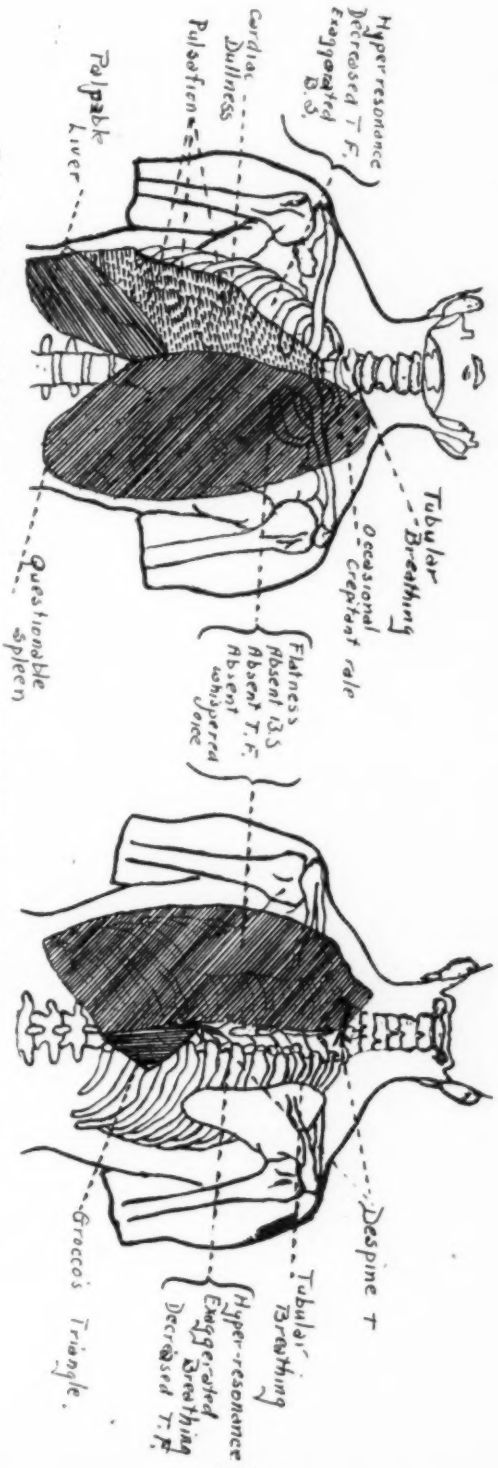

FIG. 1.—Showing physical findings. Note the complete involvement of left side with the marked displacement of the heart to the right.

13 per cent.; small mononuclears, 85 per cent.; large mononuclears, 2 per cent.; when red blood cells were centrifuged down, a straw-colored supernatant fluid remained: Rivolta test—heavy cloud of albumin; Esbach, 1.3 per cent., smear of sediment (Wright stain) showed numerous degenerated and polychromatic red blood cells, some neutrophiles and large mononuclears that were coarsely granular and

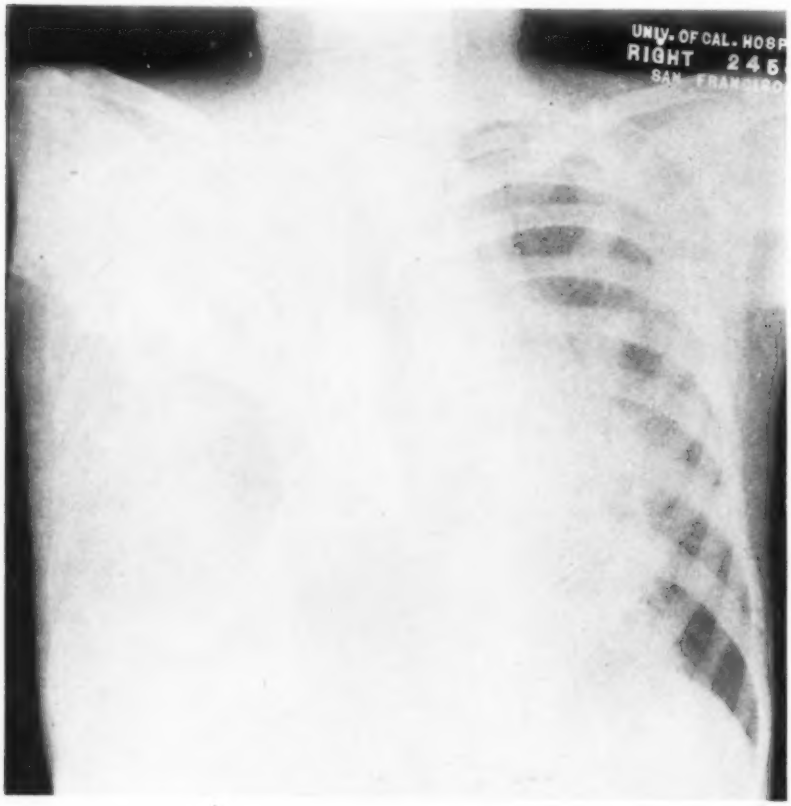

FIG. 2.—Röntgenogram taken two weeks before death, showing encroachment on left chest with heart pushed over to right.

vacuolated, no tumor cells or mitotic figures; acid fast stain, (antiformin) negative for tubercle bacilli; cultures, sterile; guinea pig inoculation, negative.

Phthalein Test (intramuscular)

1st hour	35%
2nd hour	25%
Total	60%

X-ray Reports: Fluoroscopy and chest plate, whole left lung gray, obscuring the heart outline. Mediastinal contents pushed to the right. Conclusion, large pleural effusion and question of pericardial effusion.

Kidney Plates: Large mass in left flank extending over crest of ilium which is distinctly kidney-shaped. Right kidney not clearly outlined because of gas in colon. Liver edge plainly seen.

Pathological Report (Dr. Wm. A. Perkins). Autopsy performed eight hours after death. The body was that of a normally developed but emaciated boy of ten

years. *Skin*, the superficial veins over the chest and abdomen and particularly those over the lateral aspect of the upper left chest were markedly dilated. Superficial lymph-nodes, not enlarged. Head negative. *Neck*, the jugular veins were prominently distended. *Chest*, asymmetrical, the left side noticeably larger and fuller than the right with the left interspaces obliterated. Abdomen, greatly distended, with the distention more marked on the left; the abdominal wall was tense preventing accurate palpation. Extremities, wasted. *Genitalia*, the left scrotum contained a small firm ovoidal nodule measuring 1½ x 1 x 1 cm.; this lay in a position corresponding to the left testis; the skin over it was adherent; the right testis was high in the scrotum and normal in size.

The usual mid-line incision was made; the abdominal wall was stretched and thin. *Peritoneal cavity*, contained a moderate quantity of turbid pale colored fluid (about 300 c.c.) resembling the fluid of a chylous ascites; the peritoneum was smooth; the stomach was greatly distended and occupied the mid-abdomen; no obstruction was found; to the left of the stomach in the left upper quadrant was a large mass projecting downwards from beneath the rib margin, covered by diaphragm and displacing the spleen downward, the stomach to the right, and the liver downward and to the right; retroperitoneally between the kidneys was a second mass moderately large and nodular, from the lower end of which there extended an irregularly thickened cord of tissue which could be traced along the left spermatic vessels, through the left inguinal canal and into the left scrotum; these structures will be described later. *Sternum*, on removing the sternum it was necessary to cut the left half of this structure from an underlying adherent mass; to the posterior aspect of the sternum were attached several tumor nodules of different sizes all consisting of the same type of tissue, also to be described later. *Pleural cavities*, the right pleural cavity contained a small quantity (about 150 c.c.) of pale turbid fluid similar to that found in the peritoneal cavity; adherent to the pleura on this side were large numbers of various sized tumor nodules resembling those found on the sternum; the left pleural cavity was not seen at this time. *Pericardial cavity*, was displaced completely to the right of the midline; this contained about 50 c.c. of clear straw-colored fluid.

In order the more accurately to determine the relations between the tumor masses and the viscera involved, a modified order of procedure was followed; the same order will be observed in the description of the case; the abdominal viscera were removed first: *Liver*, normal in size; on the diaphragmatic aspect of the right lobe were four small slightly elevated nodules of pale yellowish-white tissue without umbilication; on section the cut surface of the nodules bulged above the liver surface; it was pale white, homogeneous, moist, slightly translucent, fairly firm, sharply outlined, and surrounded by a narrow hemorrhagic zone of liver tissue; multiple sections of the liver revealed three other similar nodules embedded in the tissue depths; the largest of these was about 1 cm. in diameter. *Gall-bladder*, wall somewhat thickened and opaque. *Spleen*, slightly enlarged, otherwise negative. *Gastro-intestinal tract*, stomach, negative except for distention. *Small intestine*, mucosa markedly hyperæmic; 1 meter from the ileocæcal junction was a large bulbous diverticulum 5 cm. long by 2½ cm. wide with a constricted neck 1 cm. in diameter. *Large intestine*, negative. *Appendix*, 10 cm. long, adherent to cæcum. *Pancreas*, negative. *Mesentery*, contained numerous somewhat enlarged lymph-nodes; these were grossly free of tumor. *Adrenals*, appeared normal. *Kidneys*, were displaced slightly laterally by the retroperitoneal mass, the left somewhat more than the right; they were normal in size, also on section except that the pelvis of the right kidney appeared slightly dilated; the right ureter pursued a somewhat tortuous course along the outer and lower borders of the retroperitoneal mass and was slightly compressed thereby; attached to the fatty capsule of the right kidney on its deeper mesial aspect but not invading the

kidney substance was a flattened tumor nodule 2½ x 2 x 1 cm. *Urinary bladder,* negative.

The remaining viscera were removed together, and will be described as a whole, beginning with the *contents of the left chest cavity.* This consisted of a large mass everywhere adherent to the chest wall but readily separable therefrom by finger dissection. The mass was roughly kidney-shaped, corresponding to the shape of the chest cavity with hilum towards the middle mediastinum. It measured 27 x 16 x 13 cm. with a vertical circumference of 80 cm. and a lateral circumference of 53 cm. The external surface was rough and uneven, and apparently composed of greatly thickened parietal pleura. Here and there was seen a suggestion of a small tumor nodule. Inferiorly in the angle between the diaphragm and the general mass was found a definite nodule 3½ x 2½ x 1 cm. On incising the large mass along its lateral border a cavity was found containing about 400 c.c. of blood-stained fluid. This was evidently the left pleural cavity, bounded by a dense wall of markedly thickened pleura measuring from 4 to 12 mm. thick. The latter consisted of a homogeneous, firm, pale white tissue from the inner surface of which there projected inward into the pleural cavity clusters and groups of large and small tumor nodules in a most striking array. These nodules measured from 3 mm. to 8 cm. in diameter, the larger ones predominating; in shape they varied somewhat depending upon their grouping; many were compressed laterally by their neighbors, others more isolated tended to be spherical; some were pedunculated; the majority, however, were attached by a broad base; the surfaces of all were smooth, their color generally a pale yellowish-white, sometimes irregularly mottled with reddish-brown, their cut surfaces bulging, homogeneous, pale, yellowish-white, the tissue firm, rubbery, and slightly translucent, slippery and smooth but not sticky, in some instances marked by fine purplish or reddish striæ probably blood-vessels. The largest nodules were situated mesially and on section, showed enclosed the compressed remnants of the left lung. The latter appeared as two relatively narrow condensed strata of somewhat sunken dark red airless tissue separated from one another by a broad zone of coalescent tumor nodules. The lung, containing mass measured 13 x 7 x 5 cm. and of this the lung tissue proper composed about one-fourth the bulk. The pulmonary arteries and bronchioles while intimately related to the invading tumor nodules were not actually invaded by them. The *right lung* was small, 15 x 10 x 5 cm.; the pleural surface was covered by multiple small tumor nodules appearing as rounded elevations from 2 mm. to 2 cm. in diameter. Except for size these resembled the nodules described in the left chest cavity. Adherent to the mesial border of the lower lobe of the right lung was a pedunculated nodule 4 x 3 x 2½ cm. On section the right lung was red and œdematous, but without evidence of consolidation of emphysema. Embedded in the lung were a few small tumor nodules, the largest 2 cm. in diameter situated in the lower lobe. Some bronchioles and arterioles lay in the immediate vicinity of this nodule but did not pass through it. The *pericardial cavity* was compressed laterally by the large mass in the left chest. The pericardium itself appeared free of tumor invasion. The *heart* was slightly smaller than normal; otherwise it was negative. The *large vessels* entering and leaving the heart were in their normal relative positions. The left innominate vein as well as the large branches of the aortic arch were imbedded in and compressed by the upper end of the large mass in the left chest; there was, however, no actual tumor invasion. The *aorta* pursued a normal course through the chest and abdomen. Surrounding it in its abdominal portion was a *conglomerate mass of tumor nodules* 11 x 5 x 5 cm. These resembled the nodules found in the chest. They formed the retroperitoneal tumor mentioned above that lay below the diaphragm and between the kidneys. There was no apparent direct connection between this mass and the nodules in the chest. The aorta was not involved

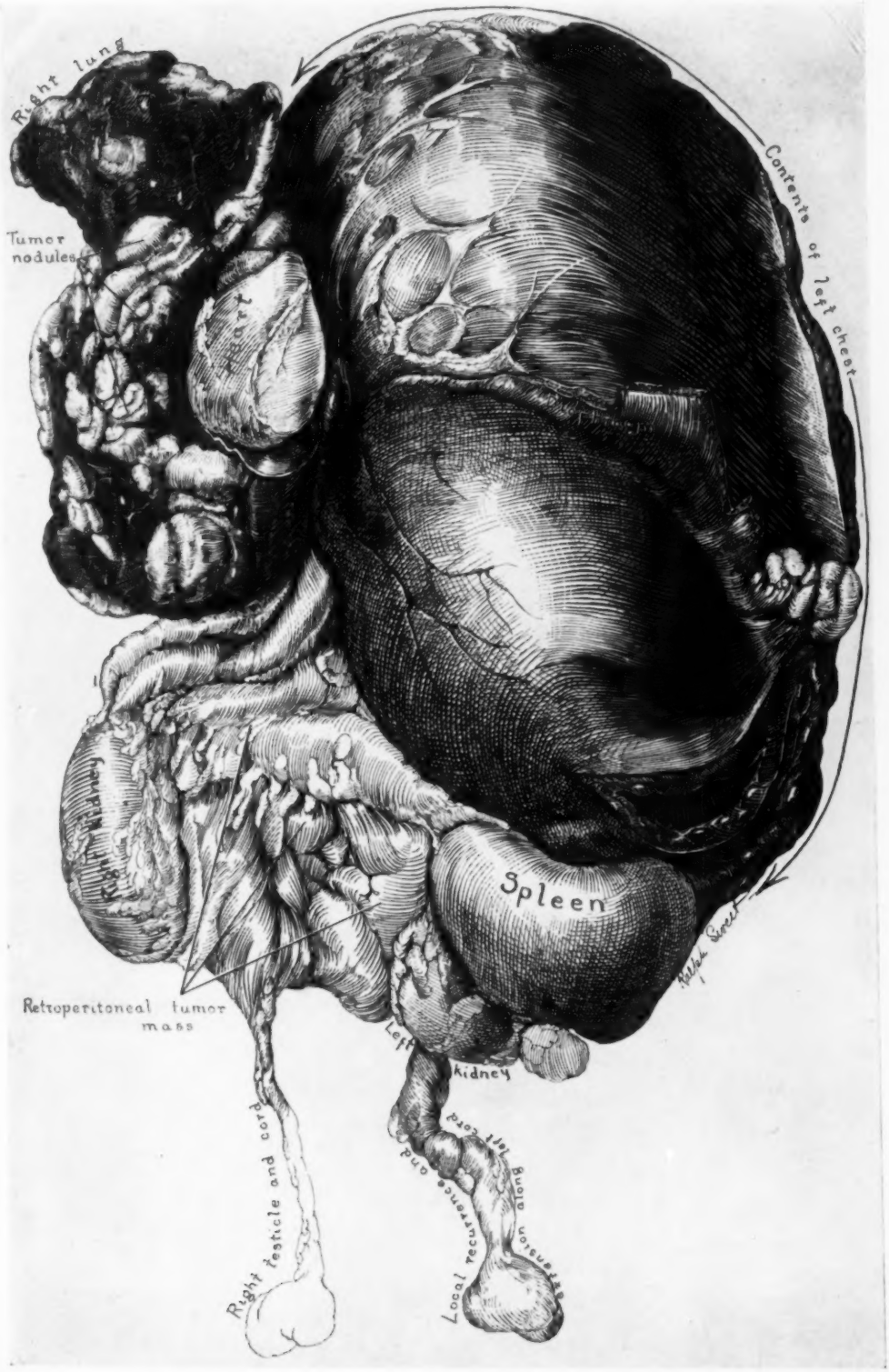

FIG. 3.—General view showing recurrent nodule in left scrotum, with extension along left cord and left spermatic vessels to retroperitoneum and thorax.

in the growth. The *inferior vena cava* was irregularly compressed by the retroperitoneal mass and on opening the vessel, a small smooth tongue-like bit of tissue was found projecting into the lumen through an aperture lying 2 cm. below the entrance of the renal veins. On section this small projection appeared directly

FIG. 4.—Left pleural cavity opened showing tumor nodules.

continuous with an adjacent extravascular tumor nodule. United to the lower end of the retroperitoneal mass on its left side was an *irregularly thickened cord* which followed the course of the left spermatic vessels downward through the inguinal canal and into the left scrotum to end in the nodule mentioned earlier in the description. Multiple sections through the cord showed these nodular thickenings to consist of tumor tissue similar to that found in the chest; they lay apparently outside the spermatic vessels. The *nodule in the left scrotum* was also composed of tumor

tissue similar to the above; no normal testicular or epididymal tissue was found on this side. The testis and epididymis on the right lay high in the scrotum but were otherwise negative.

Microscopic Report.—Sections from the *nodule in the left scrotum* show a richly cellular tissue composed of numerous undifferentiated polyhedral cells supported by a connective tissue stroma. The cells vary in their arrangement, occurring in some places diffusely or in sheets, in other places and quite frequently as more or less continuous linings of numerous small irregular spaces. The latter are formed by an anastamosing net-work of connective tissue strands and give to the growth an alveolar-like structure. The cells lining these spaces as well as those diffusely present are in general poorly defined, possessed of very little cytoplasm, and, for the most part, made up almost entirely of large vesicular nuclei. The latter contain a varying amount of chromatin, usually finely granular and fairly evenly distributed. Some of the nuclei are relatively hyperchromatic. A certain proportion possess nucleoli, though this is not a prominent feature. Mitotic figures are numerous. The stroma of the growth consists of finer and coarser strands of a pale fibrillar tissue that take the blue stain by Mallory's aniline blue method. These are present throughout the nodule, sometimes and most frequently as an exceedingly delicate reticulum, at other times appearing as a broad, smooth, branching hyalin net-work approaching a fibro cartilaginous appearance but showing no tendency to basic staining. Stroma and parenchyma are present in about equal amounts though varying somewhat in proportion in different areas. Scattered here and there throughout the stroma are a few small rather darkly staining cells, consisting of lymphocytes, neutrophiles, and degenerating tumor cells. These are far too few in number to be regarded as forming a "lymphoid stroma" so frequently described by Chevassu as occurring in "seminomes."

The tissue in general is supplied by a moderate number of small thin-walled blood-vessels. A search through several sections shows no structures or tissues other than those described. Sections through the region of the *left spermatic cord* show an encapsulated nodule composed again of undifferentiated cells in a connective tissue stroma. The cells are diffusely arranged, often widely separated as if by œdema and marked by a slight tendency to assume a spindle shape. Some of the nuclei are large, palely staining and with their chromatic material separated as if by excessive fluid; other nuclei show an irregular lobulation. Scattered here and there are small numbers of lymphocytes. In the centre of the nodule is a mass of the tumor cells completely filling a thin-walled vessel, probably a lymphatic. The *vas deferens* and accompanying blood-vessels lie outside of the nodule and do not appear to be involved. Sections through the nodular *retroperitoneal mass* show lymph-nodes in which the lymphoid stroma has been almost completely replaced by undifferentiated tumor cells. These line and fill the sinuses crowding peripherally any of the lymphoid tissue that may remain. Some of the cells here as above show a tendency to become spindle-shaped. Associated with the tumor invasion is a diffuse but scanty increase in the connective tissue stroma. Sections through the left parietal pleura show this to be tremendously thickened by invading tumor. Along the outside of the section (nearest the ribs) is a narrow strip of œdematous connective tissue representing the remains of the original connective tissue stroma of the pleura; inside this is an irregular zone of small injected blood-vessels, while within this again is the area of tumor invasion. These three zones, while roughly distinct, are yet continuous with one another.

The third or tumor zone forms an exceedingly thick coat and is composed of cells that are largely spindle-shaped. Mitotic figures are numerous. From this section alone it might be difficult to distinguish the growth from a spindle-cell

sarcoma. Sections through the *left lung* show first the visceral pleura thickened like the parietal pleura: nearest the lung is a fairly definite strip of fibrous tissue, the original fibrous tissue of the pleura and beyond this a thick layer of poorly staining tumor cells lying in a connective tissue stroma. Throughout the latter and particularly in its superficial portions are large extravasations of red blood cells. Second, from the pleura the tumor is seen to be invading the lung itself. Here the growth appears as rounded, fairly well circumscribed masses of undifferentiated polyhedral and spindle cells lying in a definite fibrous stroma. In certain places where three or more of these masses lie adjoining one another, angular-shaped remnants of lung parenchyma remain; the latter consist of squeezed and distorted alveoli, lined in part by flat atrophic epithelium, in part by large and swollen cells, often desquamated, frequently eosinophilic and occasionally fused to form large multinucleated giant cells. At the edges of these lung remnants the tumor growth can be seen to extend within the alveolar walls, with first a thickening of the latter, then a compression and distortion and finally a collapse of the included alveolar spaces. Sections from the *right lung* show a similar picture but on a much smaller scale. Here the tumor masses extend inward from the pleura as small wedges along the connective tissue septa. In advance of some of them collections of tumor cells may be seen lying free in thin-walled non-blood containing spaces, probably lymphatics, while similar spaces similarly filled are not infrequently noted within the wedge-shaped masses themselves.

Sections from the *diaphragm* show on the pleural surface massive polypoid growths composed of cells similar to those described. These are associated as above with a diffuse connective tissue stroma. One section shows the formation of small irregular spaces lined by tumor cells very much resembling the picture seen in the scrotal nodule. There is no invasion of the diaphragmatic muscle itself. Sections through the *nodules in the liver* show these to consist of polyhedral tumor cells arranged on a net-work of connective tissue strands, giving again an alveolar almost carcinomatous appearance to the growth. No spindle-shaped cells are seen. The borders of the nodules are sharply separable from the adjacent compressed liver tissue. Sections through the small *tongue of tissue* described as protruding into the venacava inferior show this to consist of tumor tissue lying in a medium sized blood-vessel and continuous with other tumor masses filling the vessel. Surrounding the vessel are multiple tumor nodules, apparently retroperitoneal lymph-nodes completely or almost completely destroyed by tumor invasion.

Briefly then we have to do with a malignant tumor originating apparently in the left testis, recurring there after removal, extending along the left spermatic cord to the retroperitoneal lymph-nodes, and thence by way of the lymphatics and blood stream to the pleuræ, lung, diaphragm, and liver. The cells composing the growth are in general embryonic in type, yet they are not without some differentiation as may be evidenced by the tendency to alveolar formation noted in the scrotum, liver and diaphragm, and by the striking resemblance to spindle-cell sarcoma seen in the left pleura and to a less extent in the lungs and lymph-nodes. Furthermore the smooth, almost cartilaginous appearance of certain areas of the stroma in the scrotal nodule suggests other differentiation. In the matter of classification we are handicapped since we were unable to secure the original tumor for examination. It is possible that the latter contained other types of tissue such as cartilage, bone, etc., or even rudiments of organs, thus putting the tumor in the group

of either embryoid or adult teratomata. In this case we would have to assume that one of the tissue composing the tumor had undergone a malignant change and outgrown all the rest. This occurrence is rare in adult teratomata, but apparently not uncommon in the embryoid type. Lacking such confirmatory evidence, however, and based on the material at hand, it would seem that the group called by Ewing embryonal carcinomata would be best

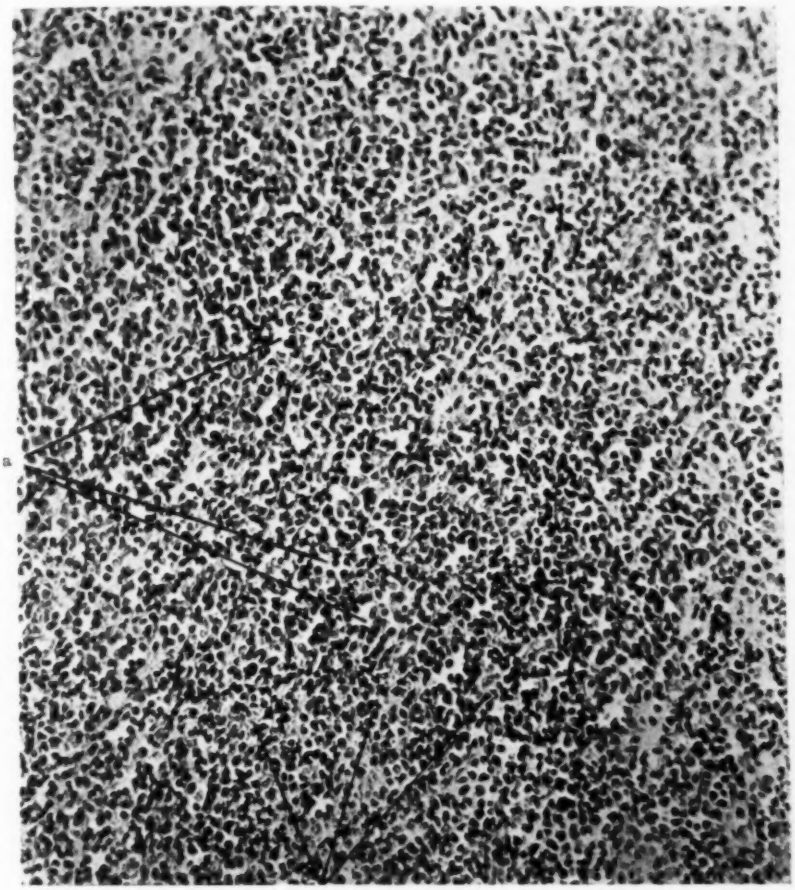

FIG. 5.—Nodule in left scrotum showing both the alveolar (a) and the diffuse (b) arrangement of tumor cells.

adapted to our case. And yet it does not compare accurately with anyone of the examples therein described. The lymphoid stroma so commonly found in that type of tumor is lacking and again the extent and size of the metastases in our case render it most unusual. Finally we cannot place the case in the group of tumors described by Chevassu as "seminomes" and included by Ewing in his class of embryonal carcinomata since in these the cells are pictured as relatively large, composed of a clear cytoplasm, possessed of nuclei rather poor in nuclear material, but provided with one or more nucleoli,

the whole supported by a stroma very small in amount and frequently marked by collections of lymphocytes, none of which features are present in our case. As much by the process of elimination, therefore, as by any other procedure, we are constrained to classify our case as an embryonal carcinoma.

Historical Note and Discussion.—As early as 1696, St. Donat described a complex tumor of the testicle in which he recognized the bones of a rudi-

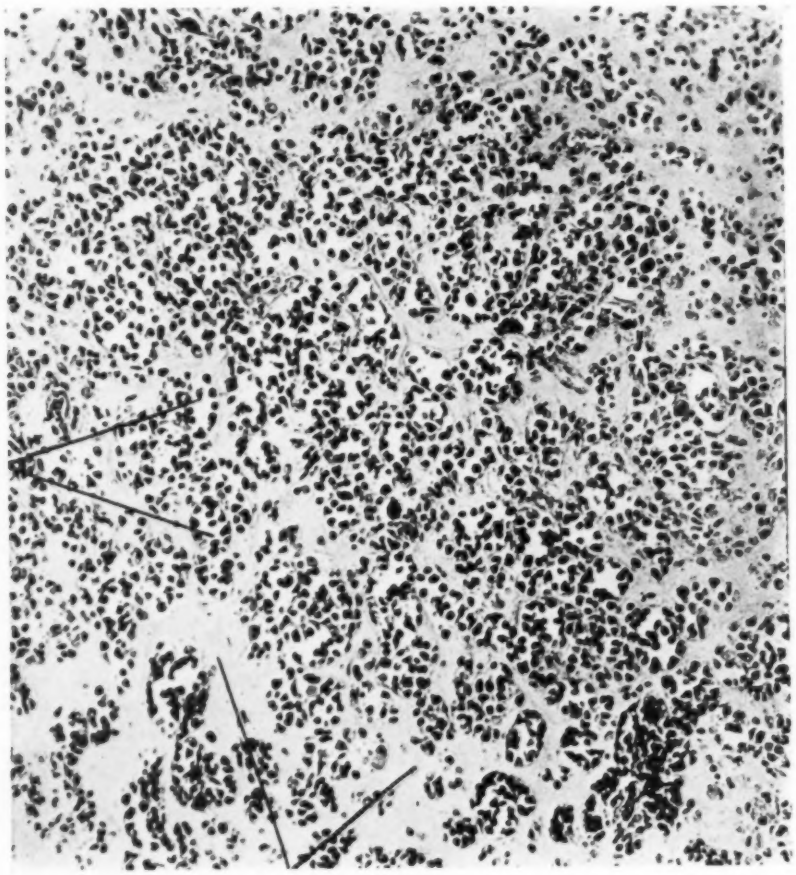

FIG. 6.—Nodule in left scrotum showing the cartilaginous-like stroma (a) also the alveolar arrangement of tumor cells (b).

mentary skull and two pigmented depressions which he interpreted as the embryonic eyes of a parasitic fœtus (Ewing). In 1845, Sir Astley Cooper wrote an elaborate treatise on the gross anatomy of teratoma testis. Johnson in 1856 was the first to recognize the tridermal constitution of such tumors. Langhans, who was apparently the first to use the microtome in his microscopic work, together with Kocher, in 1887, laid the basis for an accurate classification of testicular tumors according to microscopic structure. They were the first to suspect that the group of teratomata embraced a large proportion of all tumors of the testicle. Wilms, in 1896, was the first to

demonstrate the fact that most tumors of the testis were teratoid in nature. In 1911, Ewing presented an excellent review of the literature and a pathological study of a series of cases and came to the conclusion that practically all tumors of the testicle were of teratomatous origin.

He thus challenged the contention of Chevassu, whose exhaustive treatise was published in 1906, and that of Debarnardi appearing the same year. Chevassu demonstrated that a large proportion of tumors of the testicle were of the solid medullary, large cell type, the cells being identical in morphology and staining reactions with those of the spermatogenic cycle. He therefore

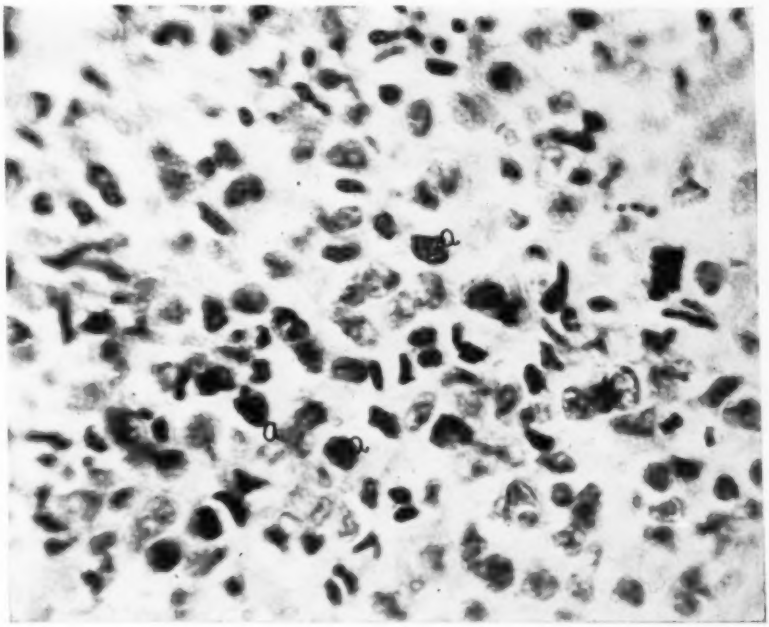

FIG. 7.—High power of Fig. 6, showing the tumor cells with scanty cytoplasm and large nuclei, some hyperchromatic (a); showing also the absence of lymphoid stroma.

derived a large proportion of testicular tumors from the spermatoblasts and called them "seminomes." Tizzoni (1876), Birch-Hirschfeld (1877), Talavera (1879), and Langhans (1887), traced in detail the gradual transition from the spermatic tubule cells, or spermatoblasts, to the so-called "seminome." Chevassu, although a champion of the spermatogenic origin of this type of growth, regarded this earlier work as unreliable, since he himself had been unable actually to demonstrate this transition.

Thus, although the classification of testicular tumors has become greatly simplified, there have arisen two opposing schools, one maintaining that "for practical purposes there exists only one tumor of the testicle, namely, a teratoma." (O'Crowley and Martland, Ewing, Wilms, Pick, Ribbert, etc.,) the other maintaining that a large proportion of testicular tumors are pure tumors (seminomes) derived from the cells of the spermatic tubules

(Chevassu, Frank, Schultz and Eisendrath, Sakaguchi, Vecchi, Birch-Hirschfeld, Tizzoni, Langhans, Talavera, Geist and Thalheimer, Hardouin and Patel, etc.).

There is probably no field in pathology where more divergent views have been and still are current. A survey of the literature shows that oncological terminology has been just about exhausted in supplying diagnoses for cases

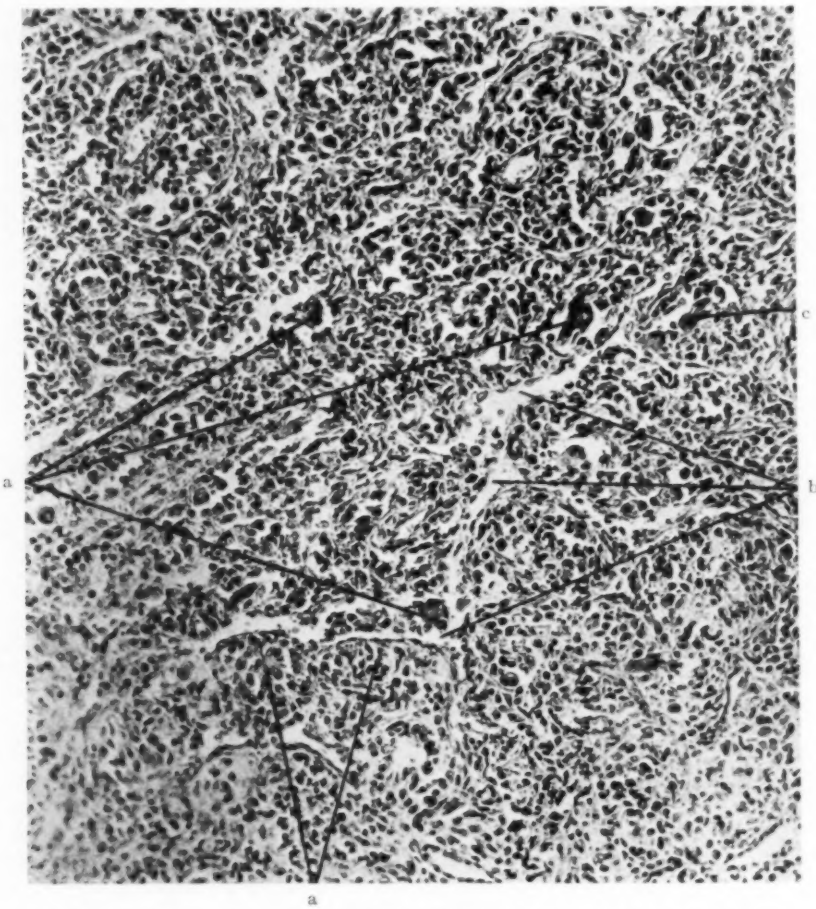

FIG. 8.—Left lung showing the tumor invasion, extension within alveolar walls (a) distortion and collapse of alveolar spaces (b) eosinophilic epithelial cells (c) "Giant Cells".

reported in spite of such contributions as that of Ewing. We cannot therefore emphasize too strongly the importance of a more general knowledge of the pathology of testicular tumors. This would seem to indicate that there exists two large groups, the teratomata (heterologous tumors) and the "seminomes" (homologous tumors), while tumors of other types are extremely rare. The following classification, which is borrowed from the noteworthy article by Schultz and Eisendrath (1921), is proposed as the most logical and complete in our present knowledge of the subject:

I. *Homologous Tumors:*
  A. *Benign:*
    1. *Epithelial:*
      (a) Adenoma of the seminal tubules [the tumors of Chevassu and of Pick (Ewing)].
    2. *Mesoblastic:*
      (a) Fibroma, arising in the tunica (the tumors of Lardennois and Lecene, Makins and Boyer).
      (b) Leiomyoma, arising in the epididymis (Ewing accepts the tumors of Trelat, Rindfleisch, and Hericourt; Schultz and Eisendrath report a similar case).
      (c) Vascular tumors (lymphangioma, hæmangioma).
      (d) Interstitial cell tumors (Ewing considers a specimen in his own laboratory and the case reported by Chevassu, as examples of hyperplasia rather than neoplasia).
  B. *Malignant:*
    1. *Epithelial:*
      (a) *Spermatocytoma* (seminome of Chevassu).
    2. *Mesoblastic:*
      (a) Sarcoma (extremely rare; possibly Sakaguchi's case and three of Miyata's cases arising in the tunics may be accepted).

II. *Heterologus Tumors:*
  A. *Benign:*
    1. *Cystic dermoid:*
  B. *Malignant:*
    1. *Embryonal carcinoma.* Heterologous tissue may be present or may have been overgrown. The atypical tissue may be:
      (a) Trophoblastic (chorio-epithelioma).
      (b) Hypoblastic (the usual adenomatous tumor).
      (c) Epiblastic (solid alveoli of basal cell type or tumors of neurocytoma type).
    2. *Sarcomatous mixed tumor* (true sarcoma in a teratoma seems to be rare).

Careful study has shown that tumors other than the spermatocytomata (homologous tumors) and the embryonal carcinomata (heterologous tumors) are of such extreme rarity as to be practically disregarded. If we accept Ewing's dictum that the spermatocytomata as such, does not exist but are forms of embryonal carcinomata, we may say that homologous tumors of the testis are so rare as to be scarcely worthy of mention, and that practically speaking there is but one type of tumor of the testis, namely teratomata (embryonal carcinomata). The vast majority of cases reported in the literature have been diagnosed some type of sarcoma, but as Ewing and Schultz and Eisendrath point out, the vast majority of malignant tumors of the testis are of epithelial and rarely, if ever, of mesoblastic origin. We must, therefore, for all practical purposes, discard the term sarcoma testis as a misnomer. An apparent exception is Ewing's case of primary lympho-sarcoma of the testis in a boy aged five and one-half years. "Seminomes" and teratomata occur with about equal frequency in the literature. Chevassu reports 59 "seminomes" and 61 teratomata. It still remains to be determined

definitely whether the so-called "seminomes" are derivatives of the epithelium of the seminiferous tubules, as Chevassu first maintained, or are to be classed as teratomata, as Ewing maintains. In a future publication from the Departments of Urology and Surgical Pathology, a careful pathological study of a series of cases will be reported with a view to adding to the evidence gradually accumulating in this discussion.

Occurrence in Children.—Five of Chevassu's 61 cases of teratomata

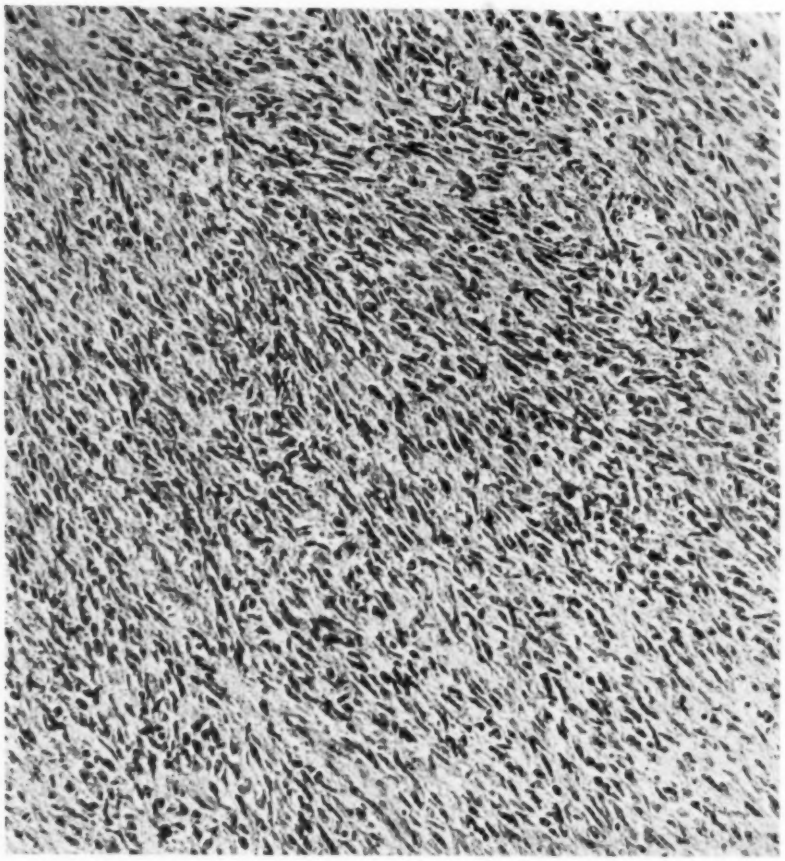

FIG. 9.—Left parietal pleura showing the spindle-shaped tumor cells.

occurred in children and none of his 59 "seminomes." Kober (1899) reviewing the English and German literature collected 107 cases of "sarcoma of the testicle." In 97 of these the age was stated and only 10 occurred in children under ten years. (His article included one case reported in this country by Deaver.) The comparatively few cases of tumor of the testis in children found after a fairly exhaustive search of the literature attest their relative infrequency as compared with their occurrence in adults. A few dermoids have been reported in children (Kelley). Ewing regards these as teratomatous in nature. Steffen and Gerhardt state that in children tumors

of the testis occur chiefly in earliest infancy, generally within the first six months or year, gradually diminishing in the second, third, and fourth years, and seldom occurring in later childhood. Kober found no cases between the ages of ten and fifteen years. Steffen concludes that the majority of these tumors are congenital. They are often noticed by the mothers at birth. In many cases there was a previous trauma. In the majority this was apparently simply a stimulus to the further development of a latent tumor.

Testicular neoplasms are relatively more frequent in undescended testes than in normally situated organs. This frequency, however, is not so great as is shown by the following table:

Relative Frequency in Undescended Testicles.

	Author	Hospital	Number of cases of undescended testicle	Number of testicular tumors	Percentage
A. Among undescended testicles in general	Eccles		859	0	
	Coley	Hospital for Ruptured and Crippled Children	1357	0	
	Kocher		1000	1	
	Brenner	Eiselberg's Clinic	75	0	
	Hoffstätter		181	4	
	Goeritz		57	1	
			3539	6	0.17

			Testicular tumors	In undescended testicle			
				Ing.	Abd.	Total	
B. Among testicular tumors in general	Howard	General	57			9	15.7
	Chevassu		128	10	5	15	11.7
	Odiorne & Simmons		54	2	4	6	11.1
	Coley		64			12	18.7
	Kober		114			18	15.8
	Hinman	Johns Hopkins	32			7	21.7
	Von Kalhden*		41			5	12.1
	Ufferduzzi		159			6	3.7

*Cited by Lipschutz, ANNALS OF SURGERY, August, 1922.

In Howard's report of 110,000 patients, 57 cases of malignancy occurred. Of these 9 occurred in undescended testicles, a ratio of 1:6⅓ (15.7 per cent.). This ratio is out of all proportion to that between abnormally and normally placed testicles which according to Rennes is 1:600 (0.16 per cent.) and according to Marshall is 1:1000 (0.10 per cent.) (quoted by Chevassu). In Chevassu's 128 cases of tumors of the testicle, 15 occurred in undescended testicles giving a ratio of 1:9 (11.8 per cent.). Odiorne and Simmons in 54 cases of malignancy found 6 in undescended testicles, a ratio of 1:9 (11 per cent.). In 64 cases of "sarcoma" observed by Coley, 12 occurred in

undescended testicles, a ratio of 1 : 5½ (18.7 per cent.). He also shows the frequency with which undescended testicles complicate hernias. In 80,736 cases of inguinal hernia occurring in male adults 1357, or 1 : 59½ (1.68 per cent.) were associated with undescended testicles. In 59,235 cases of inguinal hernia in the male sex at the Hospital for Ruptured and Crippled Children (1890–1907), there were 737 cases of "sarcoma" of the undescended testis. The frequency of malignancy in the intraäbdominal testicle

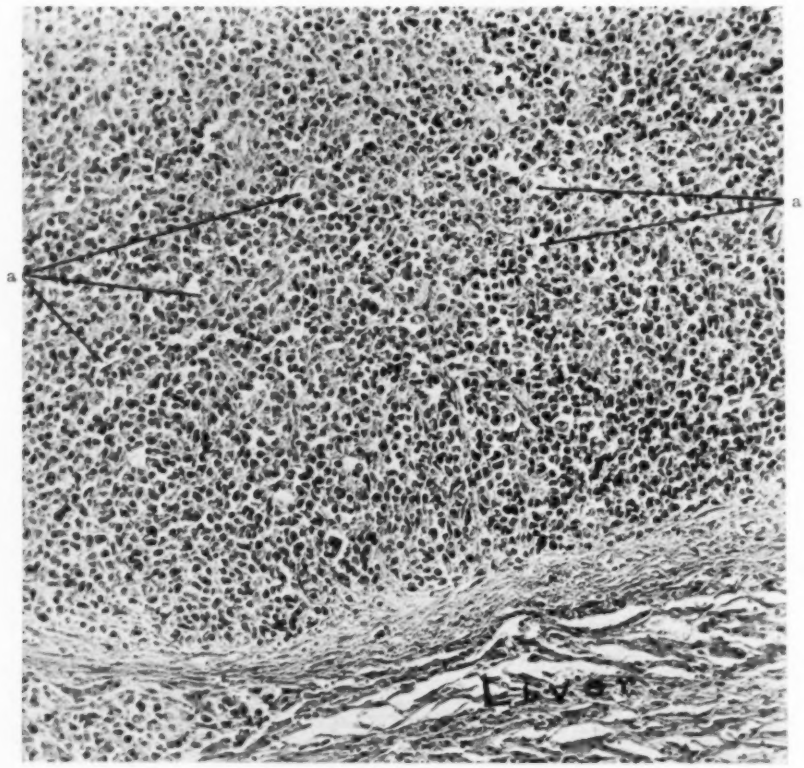

FIG. 10.—Tumor nodule in liver showing alveolar arrangement of tumor cells (a); also absence of lymphoid stroma. Picture resembles that of scrotal nodule.

is slight, the proportion here being 1 : 60,000 (0.0017 per cent.) of male admissions to general hospitals. One out of every 75 intraäbdominal testes will become malignant and 25 per cent. of malignant undescended testes are intraäbdominal (Bulkley).

Trélat states that the left testis is involved more often than the right and that very seldom both may be involved. In our review of the literature we are unable to substantiate this statement. In Chevassu's series the right was involved 56 times and the left 50. Cunningham reports a series in which the right was involved 34 times and the left 25. From these statistics and others, it appears that the frequency on the two sides is about equal. The occurrence of bilateral tumors is very rare, Chevassu, noting only one in

128 cases. Kober noted five in a series of 93, while Cunningham found three in 67.

The tumors generally resemble a hen's egg in size and shape. They are sometimes differentiated from hydrocele or hæmatocele, tuberculosis or gumma with difficulty. Their consistency varies, some are hard and nodular, others are smooth, and still others are cystic and fluctuant. According to Steffen the rate of growth varies, the hard tumors growing slowly, the soft type rapidly. They may attain the size of a man's fist or larger. The overlying skin is rarely invaded, though it sometimes becomes discolored and shows varicose veins. If the skin breaks through fatal hemorrhage may occur. The tumors generally develop without pain or symptoms of any sort. Attention may first be brought to them by their size or weight. If the tunica albuginea and outer coverings are involved, pain is present. Cachexia then appears and death follows soon after unless the termination is brought on sooner by generalized metastases. In none of the cases in children which we have been able to find in the literature have such large and extensive metastases been described as were present in our case. Lee described a case of tumor in the right testicle of a boy, age six years, which was "adeno-carcinoma" with metastases in the epididymis, both lungs, lymphatics of posterior abdominal wall, left parietal lobe of the brain and right kidney; he asserted that both the blood and lymph circulation must have been involved. A similar process occurred in our case where a tongue-like piece of tumor tissue was found projecting into the inferior vena cava. Another extensive and unusual case is the one of double teratoma reported by Lovett and Councilmann, in which the testis and head were involved independently of each other.

The type of tumor of the testicle most usually found in infancy and early childhood is the teratoma. We have found but one case of "seminome" at this age; this occurred in a boy of seven years (Hardouin and Patel). All of Chevassu's 5 cases in children were teratomata. Philipp in reviewing the literature found 42 cases of tumor of the testis in children, conspicuous among which was the great number of simple embryomata (teratomata). From the above it is apparent that teratomatas are most frequent in early infancy while "seminomes" are more usually found in later life. A glance at the following graphic illustrates this quite well. (Fig. 11.)

The prognosis of malignant tumors of the testicle is bad in both children and adults. In Kober's series of 10 cases in children, 4 died of metastases within 1 year of operation (castration); 1 was living 2 months post-operative, but with metastases in the right lower quadrant, while in the remaining 5, no end results were given. If we exclude the last 5 cases, the mortality in this series would be 100 per cent. In Steffen's series which consisted of 25 cases, including his own and others collected from the literature, 13 were dead from recurrence or metastases within 11 months after operation; 7 were living and of these 3 had had recurrences, 2 were living and well 11 months post-operative and 2 were living with their condition not stated. Two cases were

mentioned with insufficient data. No end results were given in the other 3 cases. If we eliminate the last 5 cases, there are 16 cases either living or dead with metastases and recurrences out of 20 cases. This gives a mortality of 80 per cent. There are various single case reports most of which terminated fatally in spite of operation. (Scheel, Schubert, Stenger, O'Crowley and Martland). From Chevassu's series the outlook, however, is brighter. He had 5 cases of teratomata in children out of a series of 128

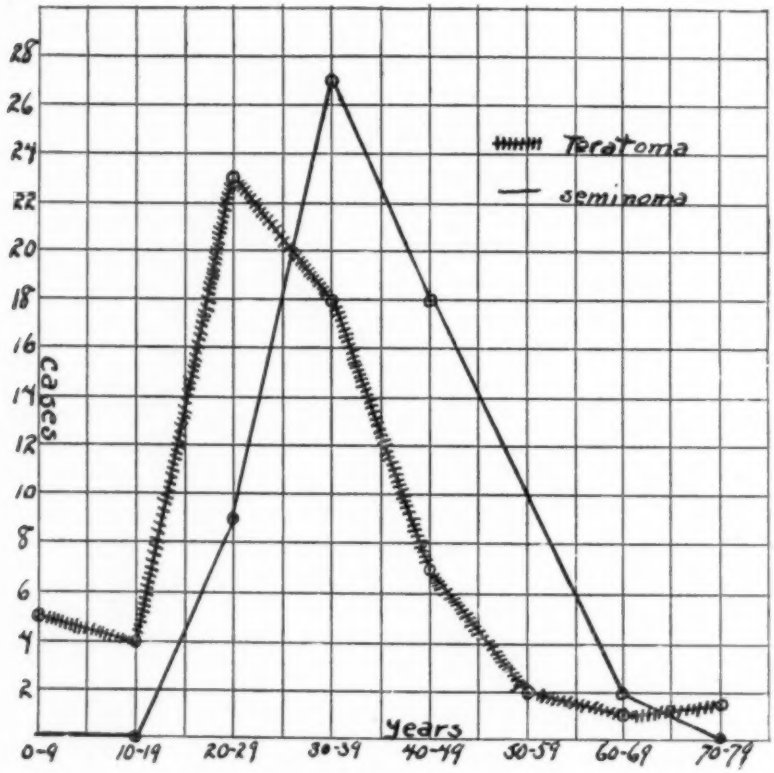

FIG. 11.—Chart (from Chevassu) showing age incidence of seminoma and teratoma. Note that there are five teratomas under the age of five years; no seminomas under the age of twenty years, and only one under twenty-seven years.

teratomata and "seminomes." Four of these cases were living and well 5 months, 2 years 6 months, 2 years 7 months, and 3 years 8 months after operation, respectively. The course of the fifth case was not known. The first case was an embryonic teratoma which is a very malignant type. The other three cases where adult teratomatas which are quite similar to dermoids, According to Ewing, this type of teratoma is far less malignant than the embryonic, hence it is not so surprising that the results in Chevassu's cases were so good. We find that Kelley has reported one such case (dermoid) living and well seven and one-half years after operation. Moran cites a case of teratoma in an 8 months' old infant that was living and well 5 years after castration. In summing up Chevassu's entire series (adults and children),

we find that the teratomatas are more malignant and run a more rapid course than the "seminomes"; that 6 out of 47 (13.8 per cent.) are living and without recurrence over two and one-half years after castration; that in the case of "seminomes," 13 out of 49 (26½ per cent.) are living and without recurrence more than one year after operation. Taking the series as a whole, 81 per cent. died and 19 per cent. lived following simple castration. There are a few cures of malignant tumor of the testis in children on record. Morrison's case was living and well 11 years after operation. Berger reported a case living and well 2 years after castration. Coley had a remarkable case in which there were local recurrences after 2 operations both performed within 5 months. A third operation was performed and a series of injections of mixed toxins of erysipelas and B. prodigiosus were given; the patient was living and well more than one year later.

From the above it is at once apparent that simple castration is inadequate. Our case illustrates that point very well. The results of the radical operation as advocated in France by Gregoire, Chevassu, etc., and in this country by Hinman, offer some hope of improvement in the treatment of these cases in the future.

SUMMARY

1. Malignant tumors of the testicle in children are comparatively rare.

2. These tumors are extremely malignant and of them, the teratoma which is found mostly in early childhood, is the most malignant.

3. The prognosis of malignant tumors of the testicle in children is very grave.

4. The mortality rate is very high and has as yet been very little influenced by present methods of treatment.

5. The case reported is probably an embryonal carcinoma of the left testicle; that this tumor is highly malignant is evidenced by the local recurrence, the extensive metastases to the lungs, right lobe of the liver and retroperitoneal lymph-nodes and by the invasion of the inferior vena cava.

We are indebted to Drs. W. P. Lucas and G. Y. Rusk, Professors of Pediatrics and Pathology, respectively, for permission to report this case and for the use of the pathological material.

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ACUTE DEFERENTITIS AND FUNICULITIS

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The earliest note on deferentitis and funiculitis appears in an old volume by Benjamin Bell, "A Treatise on Gonorrhœa Virulenta and Lues Venerea," published in 1795. Bell's description of "swellings of the spermatic cord arising as a complication of acute urethritis" is still worthy of repetition:

"It sometimes happens that inflammation of the testicle spreads to the cord, and excites pain and tumefaction along the course of it. At other times the cord inflames without any previous affection of the testis; it becomes tense, hard and painful. The swelling, for the most part, is, at first, confined to the vas deferens, but, at last, the other parts of the cord suffer also."

Bell also met with some cases "in which one or two tumefied parts were perceived in the course of the cord, while the rest of it remained sound; but, in general, the cord is equally affected, from the testis along its whole course up the groin."

Before going on to a further consideration of the subject, it may be well to review the anatomy of the structures involved. This will also aid in establishing a more logical nomenclature, since in the literature on the subject the terms "deferentitis" and "funiculitis" are sometimes used interchangeably, with resultant confusion. The differentiation will become apparent in the latter part of this communication.

It must be borne in mind that while the spermatic cord extends only from the internal abdominal ring through the inguinal canal to the testicle, the vas deferens—its main constituent—is continued through the internal abdominal ring along the lateral pelvic wall to the base of the prostate.

The spermatic cord—funiculus spermaticus—is composed of the following structures: the vas deferens accompanied by the deferential artery and veins; the spermatic artery; the pampiniform plexus of veins; the spermatic plexus; the deferential plexus of the sympathetic nerve; and the ligament of Cloquet, which is a cord-like remnant of the funicular process of the peritoneum. All of these are supported by a connective-tissue framework. The three fascial coverings of the cord are not, strictly speaking, parts of the cord proper. The spermatic cord also carries the lymphatics of the testicle, of the epididymis and of the visceral layer of the tunica vaginalis testis. The lymphatic channels follow the course of the spermatic blood-vessels and drain into the lateral and anterior aortic nodes.

The vas deferens contains three coats: (1) An internal mucous coat; (2) an intervening muscular coat; and (3) an external areolar coat. At no part of the course of the vas deferens is the latter in intimate contact

with the peritoneum except in the general neighborhood of the internal abdominal ring as it passes outwards and onwards in the inguinal canal. The presence of a hernial sac exaggerates this relationship. In the depths of the pelvis an appreciable interval separates the vas deferens and the peritoneum. The latter anatomical facts are important in the cases of deferentitis pelvica to be described later, and in the uncommon cases of peritonitis arising from this source.

Various types of acute deferentitis and funiculitis are reported in the literature. After careful consideration it seems best to divide all acute inflammatory disease of the spermatic cord into the following three main groups:

A. Acute gonococcus deferentitis and funiculitis.

B. Acute streptococcus funiculitis—"endemic funiculitis."

C. Acute funiculitis of indeterminate origin.

Acute Gonococcus Deferentitis and Funiculitis.—This complication of acute urethritis usually occurs about four weeks after the initial infection. When an acute epididymitis is also present, the symptoms and physical signs of the latter condition dominate the clinical picture. This is the ordinary form of this complication and the involvement of the vas deferens in the pathological process is either not recognized as an entity, or, possibly, even ignored by the average observer. Deferentitis and funiculitis, however, can occur without a coincident involvement of the epididymis or testis and our observations and remarks in this communication have reference to this form only.

Following the observation of Bell, quoted above, a long time passed before other cases were described. In 1868, in the *Gazette des Hopitaux*, there is a report by Gosselin of a case of funiculitis without epididymitis. The onset of the disease occurred five months after an attack of acute urethritis and the swelling and tenderness of the cord was limited to the confines of the inguinal canal. Similar cases were described by Kohn in 1870.

An interesting form of this type of deferentitis was described by Neumann in 1884, and later by Nobl in 1906. Here the inflammatory process was confined to the intrapelvic portion of the vas deferens. There were either no subjective symptoms, or merely pain on defecation. Rectal examination in these cases revealed a thickened, tender ampulla, from which the thickened vas tapered up to its point of exit through the internal abdominal ring. Externally, the vas and cord were apparently not involved. Several cases are remembered in our own hospital experience in which this condition probably existed but was not recognized. The patient was admitted with what was at first thought to be an acute appendicitis; the classical symptoms of this condition were present, including a certain amount of spasm of the rectus muscle. Physical examination showed, however, that a well-marked acute urethritis was present and in each of the few experiences of this kind, the urethral condition was the determining factor in deciding against operation. It was believed that the pathological process included an acute adenitis within the pelvis. The absence of any change in the testis and cord in the groin

led us to believe that there was no change in the pelvic portion of the vas deferens. In view of the information now available, it is fair to question the correctness of this diagnosis; probably a deferentitis pelvica was present.

In all of these cases there is most likely a focus of infection in the posterior urethra or prostate. From the latter point the gonococci can be transported to the epididymis (1) either by the lymphatics, or (2) by retrograde peristalsis of the vas deferens as described by Loeb and others. If, in their journey, the organisms penetrate the coats of the vas, a deferentitis is produced with the following typical microscopical picture: The epithelial cells of the vas become swollen and partially desquamated. There is round-cell infiltration of the submucosa and muscularis. In addition, there is an acute lymphangitis of the vas deferens, as shown by the polymorphonuclear infiltration of the lymph spaces of the muscularis. Should the infection penetrate deeper, a funiculitis is produced.

The entire process usually subsides without operative interference. However, some may go on to the formation of abscesses in the cord. Wossidlo mentions cases of funiculitis of gonococcus origin that were followed by the formation of intra-abdominal abscesses; possibly, some of the obscure and unexplained intra-abdominal abscesses that are observed from time to time on any surgical service could be explained on this basis. Gonococcus peritonitis has been noted by Zeisel.

Endemic Funiculitis.—A suppurative condition of the spermatic cord prevalent in tropical and subtropical countries was first described by Castellani in 1904 in the *Ceylon Medical Reports.* Because of its rather frequent occurrence in that region the disease was termed "endemic funiculitis."

The onset of the illness was unusually sudden. The clinical picture included: (1) a painful and tender swelling of the cord; (2) fever, which was usually high; and (3) vomiting. In some cases the epididymis (4) was also involved, but in all cases the testis proper appeared normal. Gonorrhœa, trauma, filariasis and malaria, which might possibly be thought to be the cause, were excluded in every case. There were a few mild cases which recovered spontaneously. In the majority, the disease terminated fatally with (5) bacteriæmia, (6) jaundice, and (7) cutaneous hemorrhages unless operative interference was employed.

Anatomically it was established that the spermatic cord, including the vas deferens, became inflamed, infiltrated, and swollen to a circumference of three or four inches. On section pus exuded from the veins of the pampiniform plexus and from the vas deferens.

In ninety-eight per cent. of the cases, Castellani isolated a diplostreptococcus from the pus, and in a few cases from the heart's blood at autopsy. Occasionally the same organism was isolated from the blood during life; this was usually an ante-mortem phenomenon. The organism was Gram-negative in smears of the pus and in smears from the tissues, but became Gram-positive when cultured. Castellani does not state whether the organism hæmolyzes blood. This strain of the streptococcus is not agglutinated

by the serum of patients suffering from the ordinary hæmolytic streptococcus infections. In some of the cases the organism was recovered from the urethra.

In the treatment of the endemic type of funiculitis, Castellani recommended complete removal of the cord as high up as possible.

Five years after the appearance of Castellani's paper, in 1909, five cases of funiculitis were reported from Egypt by Coutts. In this series, the disease was confined to young adults; three of them were suffering from a chronic gonococcus urethritis. Clinically, the cases were very similar to those described by Castellani. From four of the cases a diplococcus, similar to the one described by Castellani, was isolated from the tissues in pure culture. Coutts could not distinguish whether the organism was a secondary invader in chronic urethritis or the primary cause of the deferentitis.

The pathology of the lesion in Coutts' cases as exposed at operation, varied from a simple thrombosis of the pampiniform plexus to actual suppuration in the cord and surrounding structures and with definite abscess formation. In all of Coutts' cases the epididymis and testis were not involved. The treatment practised by Coutts was more conservative than that of Castellani; multiple incisions into the swollen tissues with evacuation and drainage of abscess cavities were the only procedures carried out. All of the patients in this series recovered uneventfully.

In 1907, Madden reported two cases of "Cellulitis of the Spermatic Cord" occurring in natives of India. Clinically and pathologically they resembled Castellani's and Coutts' cases in every detail except for the presence of an inflamed hernial sac attached to the cord. In each case the cord was enormously thickened; the veins of the cord were filled with purulent thrombi and there were numerous small abscesses scattered throughout the cord structures. In each case the affected cord was completely excised and an uneventful recovery ensued. Although this paper appeared after that of Castellani, no mention is made of any bacteriological studies.

Jones' case, reported in 1909, from Egypt, is similar to those described by Madden in that a hernial sac was present. Here, again, more definite bacteriological studies might have helped in the classification of the case. At operation the cord was found to be acutely inflamed and markedly thickened; the contents of the hernial sac were irreducible. A further complication was noted: The vermiform appendix, acutely inflamed, was found embedded in the cord structures. While Jones was well aware of the possibility of a primary acute appendicitis with secondary cord involvement as the sequence of events in this case, yet, from his clinical observation, he insisted upon the reverse sequence as the correct explanation.

The series of cases, reported in 1891 by Brown from India, are similar to the series of cases reported above and differ only in that the pathological process had produced more extensive changes; *i.e.*, there was a tendency towards larger abscess formation.*

* We exclude from this discussion the series of thirty-six cases of funiculitis reported by Menocal from Cuba, in which the filiarial organism was proven to be the etiological factor.

Comment.—All of the available evidence points to the fact that this type of lesion is, essentially, a thrombo-phlebitis of the pampiniform plexus of the cord. The lesion is most extraordinary. There is a complete lack of evidence which could point to the presence of any focus in the body which might act as a primary lesion and to which the thrombo-phlebitis might be secondary; and Madden's belief that this etiology is present has not in any way been substantiated. Apparently this is a disease peculiar to tropical countries. One does not have sufficient information of the biological phenomena of the streptococcus isolated in the reported cases to enable one to classify the organism properly. Whether the latter is the organism which is so prevalent in our own and other countries, or whether it is a strain to be found only in certain of the tropical countries still remains to be proven. It is still quite possible that the disease is due to some parasite, which, as yet, goes undiscovered; then the streptococcus might play the rôle of a secondary invader, or, even, of a contaminant.

Acute Funiculitis of Indeterminate Origin.—The essential characteristics of the cases in this group are best illustrated by the following case reports:

Hospital No. 220068. The patient, an unmarried man of forty-six years, was admitted to the hospital on April 12, 1923, complaining of a painful swelling in the left groin of ten days' duration. Thirty years before he had had typhoid fever; twenty years before, rheumatic fever with cardiac involvement. Venereal infection of any kind was denied.

The present illness began with an attack of "influenza" three months prior to admission of the patient to the hospital. The patient had had fever, slight chills and symptoms of a cold in the head for about one week. A few days later he complained of pain in the right ear; a myringotomy was then performed, following which pus continued to discharge from the ear for some time. Thereafter up to the time of admission to the hospital, the patient had felt below par.

About ten days before admission, the patient awoke one night with severe pain in the lower abdomen, mostly on the left side, shooting down into the thigh. At the same time he noticed a tender swelling in the left groin, which gradually increased in size. There were slight chilly sensations, moderate fever and malaise.

On examination in the hospital, a firm tender swelling was found in the left groin, cylindrical in shape and corresponding to the shape, extent and direction of the spermatic cord. The left half of the scrotum was slightly reddened but the testis and epididymis felt normal. There was a difference of opinion as to whether a mass could, or could not be palpated in the pelvic cavity by rectal examination. There was no urethral discharge; no enlargement or tenderness of the prostate or vesicles. In addition to these local findings, there was a chronic suppurative otitis media on the right side with perforation of the membrana tympani; also a compensated mitral insufficiency.

On the day of admission to the hospital, the patient's temperature was 102° F. The blood examination showed a leucocytosis of 42,000 with a polynucleosis of 92 per cent. The urine contained albumin, casts and a few white cells. The urine was not purulent.

The pre-operative diagnosis was abscess of the abdominal wall. At operation the inguinal canal was opened throughout its entire length and the spermatic cord was found thickened to a diameter of four centimetres, with all of the structures matted together with inflammatory and doughy exudate. There was no fluid pus present. Aspiration of the deeper structures also showed no fluid pus. A small tube was left in the canal and the outer wound was closed down to the point of

emergence of the tube. Aspiration, for exploratory purposes, was done through the rectum at a later date but with negative results. There was practically no discharge from the wound and the latter healed uneventfully. The pain and swelling in the groin decreased at first and, later, disappeared entirely.

During the convalescence some slight pain and swelling appeared in the right groin; this was transient and disappeared after several days. At the end of the second week the patient was discharged from the hospital cured of his ailment.

An attempt was made to find a possible etiological factor; but, in this, we were unsuccessful. Smears from the cord structures showed only a saprophytic Gram-positive bacillus and pus cells. The prostate was massaged and the material thus obtained showed numerous Gram-positive lancet-shaped diplococci in short chains in addition to a few clumps of pus cells. Culture of this material yielded only a hæmolytic staphylococcus albus in pure culture. Smears of the pus from the right ear were negative; and the blood complement fixation test for gonococci was also negative.

Somewhat similar to the above case is the one described by N. R. Smith in 1834 in the *Archives of the Medical and Surgical Sciences*. Apparently this is the only reference to this subject which we have been able to find in the American literature up to the present writing. The case described is of a "morbid state of the spermatic cord simulating hernia" occurring in a young man.

The patient had been complaining of a painful swelling in the left inguinal region for three days. In addition, there were other symptoms, including vomiting, which suggested the diagnosis of strangulated hernia. There was some œdema of the scrotum and a distinct swelling along the course of the left inguinal canal. An incision was made as for a strangulated hernia, but, on exposure of the cord, it was found to be greatly enlarged due to "infiltration of serum into its layers." The patient did poorly after operation and died the next day. At the post-mortem examination in addition to the local findings, there was found signs of "peritoneal inflammation." No mention is made of the gonococcus as a possible etiological factor.

It is possible that the sero-fibrinous inflammation present in the preceding two cases may be only one phase of a more severe process. A more virulent infection or a lowered resisting power on the part of the patient would then lead to the development of pus with abscess formation, confined at first to the cord, and spreading later to the surrounding structures. These cases might be classified as "acute funiculitis with abscess formation." Such a case, apparently, is the one reported by Hamilton in 1844. The clinical picture was typical of acute funiculitis and at operation a localized abscess of the cord was found. Hamilton believed that the abscess had occurred as the result of infection of an encysted hydrocele of the cord; the etiological relationship is rather of a theoretical nature in the absence of more substantial proof. No organisms were recovered from the pus. In another case of acute suppuration of the cord described by Dupraz the colon bacillus was isolated from an extensive foul-smelling abscess.

As an illustration of the manner in which a primary suppuration of the spermatic cord may spread, the following clinical notes are given; we are indebted to the service of Doctor Beer for them:

Hospital No. 209001. A forty-nine year old man was admitted to the hospital complaining of a painful swelling in the right groin of 5 weeks duration. Except for an attack of gonorrhœa, thirty-one years before, there had been no preceding illness. The pain in the groin soon extended to the scrotum and three weeks before admission to the hospital, perforation of the latter organ occurred with the discharge of pus. There was only slight fever and no vomiting. Upon admission to the hospital there was found a tender fluctuating mass in the right groin and the cord was thickened and tender. The epididymis also felt firm and tender and by rectal examination a tender mass could be palpated above the prostate.

At operation, pus was found superficial to Poupart's ligament coming through the external ring. On opening the canal the cord was found to be greatly thickened and inflamed; the vas deferens, nodular and beaded. A second abscess was found beneath the external oblique muscle extending upwards for about four inches. The pus was evacuated and the cavity packed with iodoform gauze. At the end of three weeks the wound healed completely; the nodular thickening of the vas deferens disappeared and the scrotal sinus had closed.

Smears and cultures of the pus were negative bacteriologically. The Wassermann reaction was also negative. The importance of the gonococcus infection as an etiological factor is extremely problematical.

Comment.—The third group of cases of deferentitis and funiculitis—those of indeterminate nature—is extremely interesting because of the entire lack of evidence pointing to a satisfactory etiological cause. Among the factors to be considered are (1) trauma, (2) a preëxisting infectious disease such as rheumatism or influenza, and (3) the presence of any focus of infection and suppuration to which the funiculitis might be considered as a metastatic phenomenon.

1. Does trauma play any rôle in the etiology of the cases in this group? Turner, in 1886, described a case occurring in a three months' old child who had been kicked in the scrotum a few days before the development of a painful, tender, fluctuating swelling in the groin. This was incised, pus was evacuated from the inguinal canal and, thereafter, the wound healed uneventfully. To be sure, this is an isolated case; and in none of the others did there seem to be such a close relationship to a preceding trauma.

2. French writers mention, but do not go into further detail or discussion of rheumatic fever and gout as etiological factors in funiculitis. It is true that our first patient gave a history of an attack of rheumatic fever and that a cardio-valvular defect was present; but the interval of time between the latter and the funiculitis makes the etiological connection rather weak; and, during the course of the lesion in the cord, there was no clinical evidence of any possible associated rheumatic manifestation.

In our first case there was a history of an attack of "influenza" three months before the onset of the pain and swelling in the cord. It is, of course, possible, too, that the influenza becomes operative as an initial focus because of the development of some intermediate lesion, such as a middle ear infection. However, this, also, is an isolated instance.

In any case, therefore, the value of any infectious disease as an etiological factor in connection with any case of funiculitis is extremely problematical because of the paucity of laboratory, clinical or other evidence.

3. The possibility of the funiculitis occurring as a metastatic infection secondary to another suppurating focus—in our case a middle-ear infection—must also be considered. In our experience at the hospital, metastatic foci of this kind secondary to middle-ear infections are extremely rare, except when a sinus thrombosis is present. In our patient there was no clinical evidence of such a complication. In addition, bacteriological examination of the ear was negative and the smears of the cord showed only a saprophytic organism which was most likely a contaminant. Evidence in this regard is, therefore, also, lacking.

Differential Diagnosis.—The differential diagnosis of acute funiculitis of this type is extremely difficult at times. Clinically, funiculitis may simulate any number of varied surgical conditions, and the surgeon may be confronted with unexpected findings when operating upon a patient with a swelling in the groin. The following conditions must be borne in mind and differentiated before arriving at a diagnosis.

1. Abscess of the abdominal wall. This is a very common diagnosis made before operation in cases of acute funiculitis. This was the circumstance in both of our cases. A localized collection of pus may occur at any point of the abdominal wall. Such an abscess may be of any size; may be subcutaneous; or may be in the deeper layers of the abdominal wall. If an abscess does form in the groin, its extent and direction with relation to the inguinal canal must be considered in arriving at a diagnosis.

2. Irreducible hernia. In the endemic type, this was the most frequent pre-operative diagnosis made, because of the similarity of the symptoms and physical signs at the onset of both conditions. In both cases there is usually a tender swelling in the groin with absence of impulse on coughing. However, in cases of irreducible hernia the tenderness is more apt to be localized to the neck of the sac. In funiculitis the tenderness will extend along the entire length of the cord and may even be elicited from the epididymis of the corresponding side. In neither condition need there be any appreciable change in the overlying skin. Redness and œdema may be entirely absent. The presence of fever and leucocytosis favor the diagnosis of an inflammatory process. In the severe cases of funiculitis with rapid onset, vomiting and persistent constipation are prominent symptoms and are of such intensity as to resemble acute intestinal obstruction. One can see how, with the addition of the local findings, a diagnosis of irreducible hernia with ileus can be incorrectly made.

Where acute funiculitis is suspected and a history of a preëxisting hernia on that side is obtained, the former diagnosis cannot be ruled out because in some of the cases reported in the literature an inflamed hernial sac has been found in addition to the inflammation of the spermatic cord. In the case described by Jones, both conditions were present, namely, funiculitis and an irreducible hernia on the same side.

3. Appendicitis with abscess. If the swelling of the cord is rather high up towards the internal inguinal ring, it may very well be mistaken for a mass in connection with an acute appendicitis. In the latter condition such a mass can be produced by a thickened omentum rolled around an inflamed appendix, or by a localized abscess. The symptoms and history may be the same in both conditions. Rectal examination would not be of much aid in the differentiation because in either condition there may be nothing more than a slight tenderness, due, in the case of appendicitis, to the low-lying appendix, or appendicular abscess, and, in the case of funiculitis, to the involvement of the vas deferens in the inflammatory process. However, a tender, well-outlined, definitely thickened vas deferens felt by rectum, together with the swelling in the groin, is more in favor of a spermatic cord involvement.

4. Abscess in a hernial sac. Another condition, though of greater rarity, that may cause difficulty in diagnosis, is the occurrence of an abscess forming in a hernial sac. Such an abscess may have an acute appendicitis as the primary cause, or a segment of gangrenous omentum, or twisted epiploic appendage. It seems quite evident that the correct diagnosis in these cases is to be made only at operation unless some other factor, capable of giving one a correct clue, is present.

5. Thrombosis of varicose veins of the cord. The clinical picture and pathological anatomy of the condition described under the third grouping in this communication is not a thrombosis of blood-vessels. The latter would produce a thickening of the cord without sign or symptom of an inflammatory process. Also, varicose veins would have been present before the onset of the acute illness.

6. Hæmatoma of the cord. A history of trauma and the absence of inflammatory changes would favor such a diagnosis. An abscess might, however, develop later as in the case reported by Turner.

7. Tuberculosis of the vas deferens. Tuberculosis may be associated with secondary changes in the cord. There is usually an advanced lesion in the epididymis. This is a chronic illness.

8. Gumma of the cord. The course is chronic. The cord is, as a rule, not tender. The Wassermann reaction of the blood is positive. With the administration of appropriate antiluetic treatment the swelling diminishes.

9. Neoplasm of the cord or in the inguinal canal. Various neoplastic formations occur in the cord. It is not necessary to go into a detailed description of them here. Suffice to say, that one ought to recognize the differences in the duration of the illness and the differences in the local findings. However, an infected neoplasm of the cord could give considerable difficulty in diagnosis.

10. Osteomyelitis or infected neoplasm of the os pubis must also be considered in the differential diagnosis. The röntgenographic findings aid in the differentiation.

3. The possibility of the funiculitis occurring as a metastatic infection secondary to another suppurating focus—in our case a middle-ear infection—must also be considered. In our experience at the hospital, metastatic foci of this kind secondary to middle-ear infections are extremely rare, except when a sinus thrombosis is present. In our patient there was no clinical evidence of such a complication. In addition, bacteriological examination of the ear was negative and the smears of the cord showed only a saprophytic organism which was most likely a contaminant. Evidence in this regard is, therefore, also, lacking.

Differential Diagnosis.—The differential diagnosis of acute funiculitis of this type is extremely difficult at times. Clinically, funiculitis may simulate any number of varied surgical conditions, and the surgeon may be confronted with unexpected findings when operating upon a patient with a swelling in the groin. The following conditions must be borne in mind and differentiated before arriving at a diagnosis.

1. Abscess of the abdominal wall. This is a very common diagnosis made before operation in cases of acute funiculitis. This was the circumstance in both of our cases. A localized collection of pus may occur at any point of the abdominal wall. Such an abscess may be of any size; may be subcutaneous; or may be in the deeper layers of the abdominal wall. If an abscess does form in the groin, its extent and direction with relation to the inguinal canal must be considered in arriving at a diagnosis.

2. Irreducible hernia. In the endemic type, this was the most frequent pre-operative diagnosis made, because of the similarity of the symptoms and physical signs at the onset of both conditions. In both cases there is usually a tender swelling in the groin with absence of impulse on coughing. However, in cases of irreducible hernia the tenderness is more apt to be localized to the neck of the sac. In funiculitis the tenderness will extend along the entire length of the cord and may even be elicited from the epididymis of the corresponding side. In neither condition need there be any appreciable change in the overlying skin. Redness and œdema may be entirely absent. The presence of fever and leucocytosis favor the diagnosis of an inflammatory process. In the severe cases of funiculitis with rapid onset, vomiting and persistent constipation are prominent symptoms and are of such intensity as to resemble acute intestinal obstruction. One can see how, with the addition of the local findings, a diagnosis of irreducible hernia with ileus can be incorrectly made.

Where acute funiculitis is suspected and a history of a preëxisting hernia on that side is obtained, the former diagnosis cannot be ruled out because in some of the cases reported in the literature an inflamed hernial sac has been found in addition to the inflammation of the spermatic cord. In the case described by Jones, both conditions were present, namely, funiculitis and an irreducible hernia on the same side.

3. Appendicitis with abscess. If the swelling of the cord is rather high up towards the internal inguinal ring, it may very well be mistaken for a mass in connection with an acute appendicitis. In the latter condition such a mass can be produced by a thickened omentum rolled around an inflamed appendix, or by a localized abscess. The symptoms and history may be the same in both conditions. Rectal examination would not be of much aid in the differentiation because in either condition there may be nothing more than a slight tenderness, due, in the case of appendicitis, to the low-lying appendix, or appendicular abscess, and, in the case of funiculitis, to the involvement of the vas deferens in the inflammatory process. However, a tender, well-outlined, definitely thickened vas deferens felt by rectum, together with the swelling in the groin, is more in favor of a spermatic cord involvement.

4. Abscess in a hernial sac. Another condition, though of greater rarity, that may cause difficulty in diagnosis, is the occurrence of an abscess forming in a hernial sac. Such an abscess may have an acute appendicitis as the primary cause, or a segment of gangrenous omentum, or twisted epiploic appendage. It seems quite evident that the correct diagnosis in these cases is to be made only at operation unless some other factor, capable of giving one a correct clue, is present.

5. Thrombosis of varicose veins of the cord. The clinical picture and pathological anatomy of the condition described under the third grouping in this communication is not a thrombosis of blood-vessels. The latter would produce a thickening of the cord without sign or symptom of an inflammatory process. Also, varicose veins would have been present before the onset of the acute illness.

6. Hæmatoma of the cord. A history of trauma and the absence of inflammatory changes would favor such a diagnosis. An abscess might, however, develop later as in the case reported by Turner.

7. Tuberculosis of the vas deferens. Tuberculosis may be associated with secondary changes in the cord. There is usually an advanced lesion in the epididymis. This is a chronic illness.

8. Gumma of the cord. The course is chronic. The cord is, as a rule, not tender. The Wassermann reaction of the blood is positive. With the administration of appropriate antiluetic treatment the swelling diminishes.

9. Neoplasm of the cord or in the inguinal canal. Various neoplastic formations occur in the cord. It is not necessary to go into a detailed description of them here. Suffice to say, that one ought to recognize the differences in the duration of the illness and the differences in the local findings. However, an infected neoplasm of the cord could give considerable difficulty in diagnosis.

10. Osteomyelitis or infected neoplasm of the os pubis must also be considered in the differential diagnosis. The röntgenographic findings aid in the differentiation.

11. A psoas abscess can appear in the groin and conceivably be mistaken for a funiculitis. The röntgenographic evidence and clinically objective findings should suffice to make the correct diagnosis.

Treatment.—In the gonorrhœal cases, where no pus has formed, operative interference is contra-indicated. Under conservative forms of treatment, as for any of the other usual gonorrhœal complications, the funiculitis usually subsides. Where, however, pus has formed, adequate incision and drainage is indicated.

In the endemic or tropical type, where the cord is riddled with small abscesses, complete excision of the cord is recommended; the wound should not be sutured, but kept wide open with gauze packings.

In the cases of indeterminate etiology, with or without abscess formation, incision down to the cord and evacuation and drainage of abscesses, whenever present, is indicated.

SUMMARY

Acute deferentitis and funiculitis may be classified into three main groups: 1. Cases of gonorrhœal origin. 2. Cases due to streptococcus infection—an endemic type in tropical countries—the essential lesion being a thrombo-phlebitis. 3. Cases of indeterminate etiology with and without abscess formation.

Two cases of the third group are described. Both were operated upon and recovered uneventfully.

The importance of the differential diagnosis of this disease is emphasized.

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TRANSPUBIC REMOVAL OF THE PROSTATE FOR CARCINOMA

By George Walker, M.D.
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In the Annals of Surgery of May, 1921, I suggested a preliminary symphysiotomy in the removal of cancer of the prostate. I had carried out

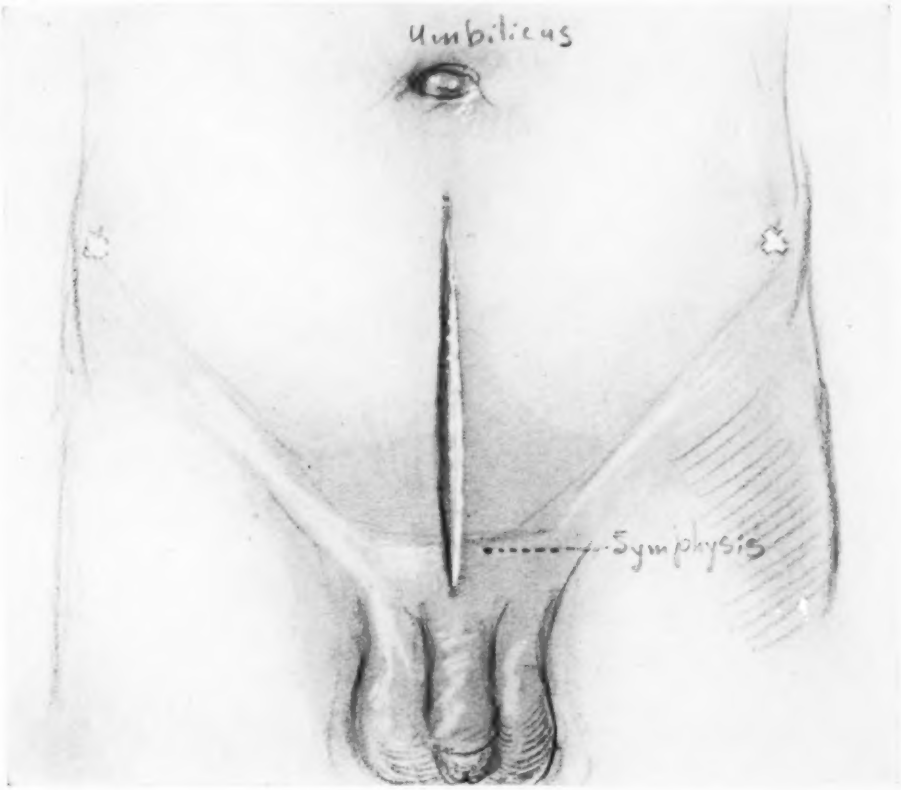

Fig. 1.—Initial incision.

this operation a number of times on cadavers, and was impressed with its feasibility.

Within the past year it has been employed twice on human beings.

The following steps, somewhat modified from the original publication, were carried out:

1. Make an incision from one inch below the umbilicus to a point over the middle of the pubis, as is shown in Fig. 1.

2. Expose the bladder in the same manner as in an ordinary suprapubic operation.

3. Open the bladder to confirm the diagnosis and to ascertain the extent of the invasion of the vesical neck. (See Fig. 2.)

4. Cut through the cartilage joining the pubes, and separate the bones slightly. Then divide the pubic ligaments and attachments of the triangular ligament. This should be done with a blunt-pointed knife.

5. Place the special retractor between the cut ends of the bone and

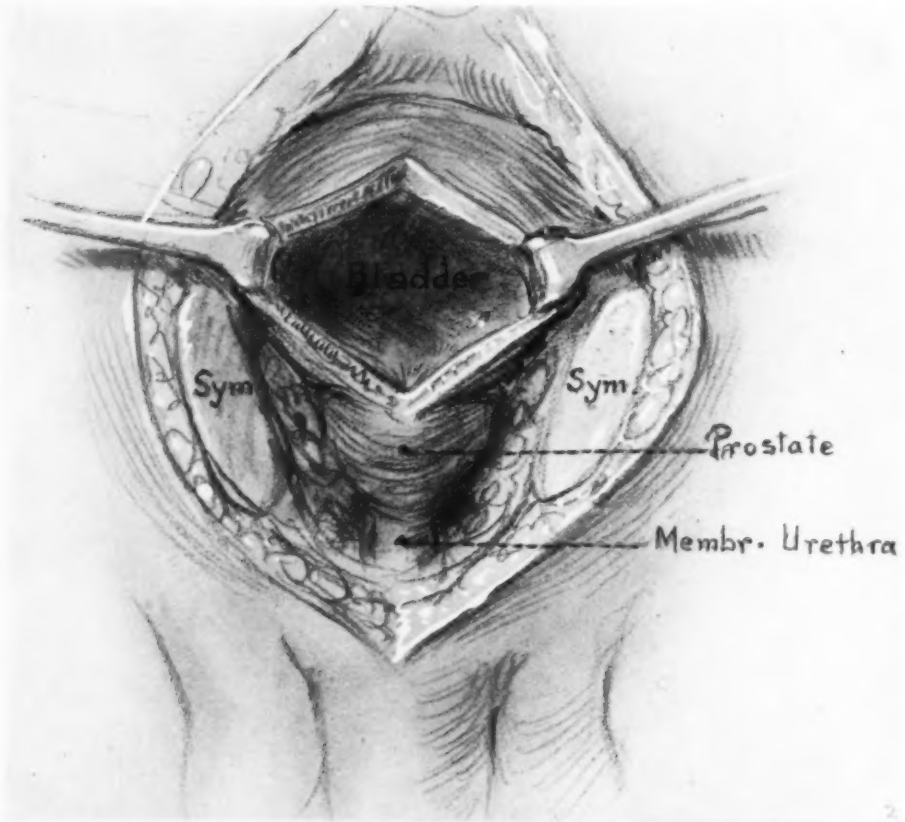

FIG. 2.—Bladder opened for confirmation of diagnosis and for invasion of vesicle of neck.

separate the surfaces as widely as desired. Abduction of the legs aids the separation. (See Fig. 8.)

6. As the bones are separated, the prostate comes into view. The lateral surfaces of the gland are then freed from the surrounding tissue by the operator's hand. This separation is carried down to the rectal wall.

7. The urethra is now cut across at its juncture with the prostate.

8. The prostatic end of the urethra is grasped with the forceps and pulled upward and forward so as to allow the prostate to be dissected, under view, from the rectum. This should be done with great care. The dissection is carried well up toward, but not quite, to the bladder.

9. Divide the bladder transversely as near the vesical neck as is war-

ranted by the growth. Our aim should always be to leave the thickened band of muscle which forms the internal sphincter.

10. After the circular incision of the bladder, the remaining attachment of the bladder is carefully divided. (See Fig. 3.)

11. Suture the cut end of the urethra to the posterior angle of the wound with 28-day catgut, as shown in Fig. 4.

12. After the preliminary posterior suture pass a catheter and complete the sutures around it (Fig. 5).

13. Close the bladder from the juncture of the urethra upward, leaving an opening three-quarters of an inch in length for the reception of a drainage tube (Figs. 5 and 6).

FIG. 3.—Shows cut ends of urethra and bladder and cavity from which prostate was removed.

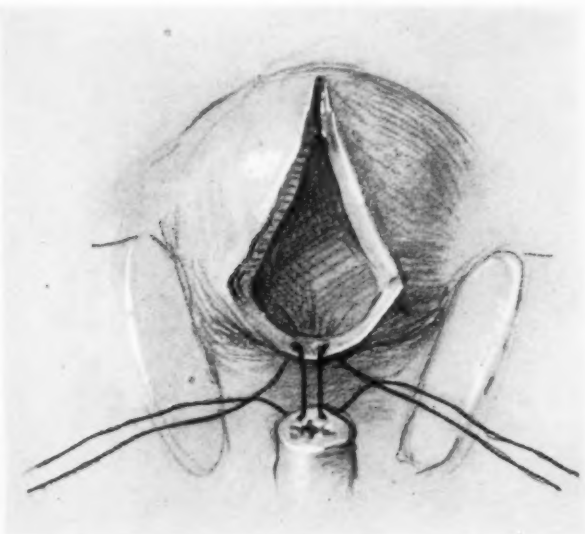

FIG. 4.—Preliminary suture approximating cut end of the urethra to posterior angle of wound of bladder.

14. Close the symphysis with heavy silver-wire (Fig. 6). In both of these two patients the wires failed to hold; hence it is thought that a snugly fitting binder made of stiff cloth and buckles would answer the purpose better. In the case of a recent patient (not carcinoma) only the binder was used, and the recovery and union were satisfactory. The binder, shown in Fig. 7, has been found quite suitable.

15. Place the proper drain and close the wound.

After-care: When the patient is removed from the operating table he

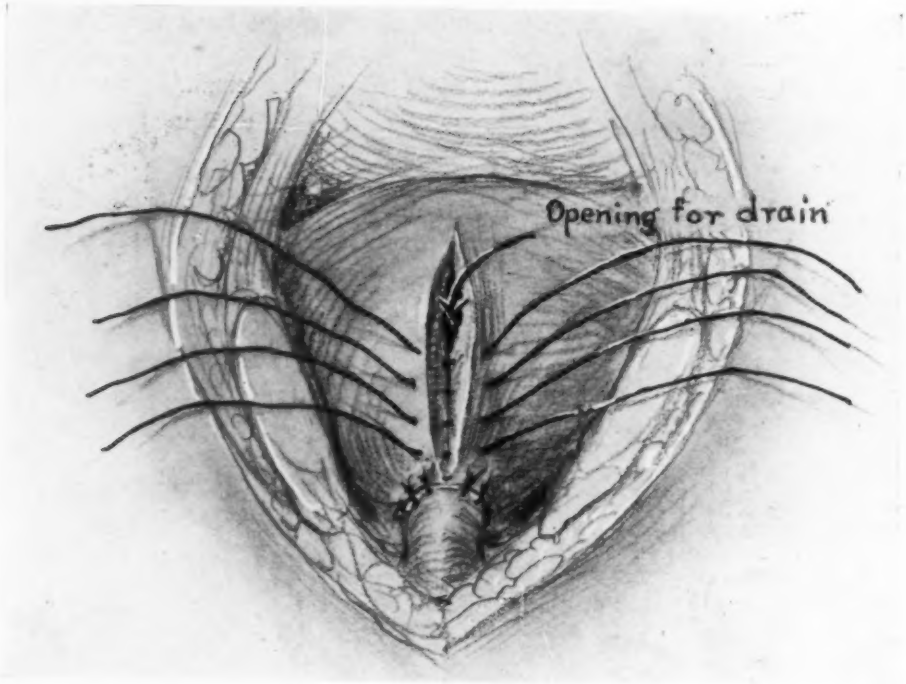

FIG. 5.—Completion of urethra and bladder suture, with sutures placed for partial closure of bladder.

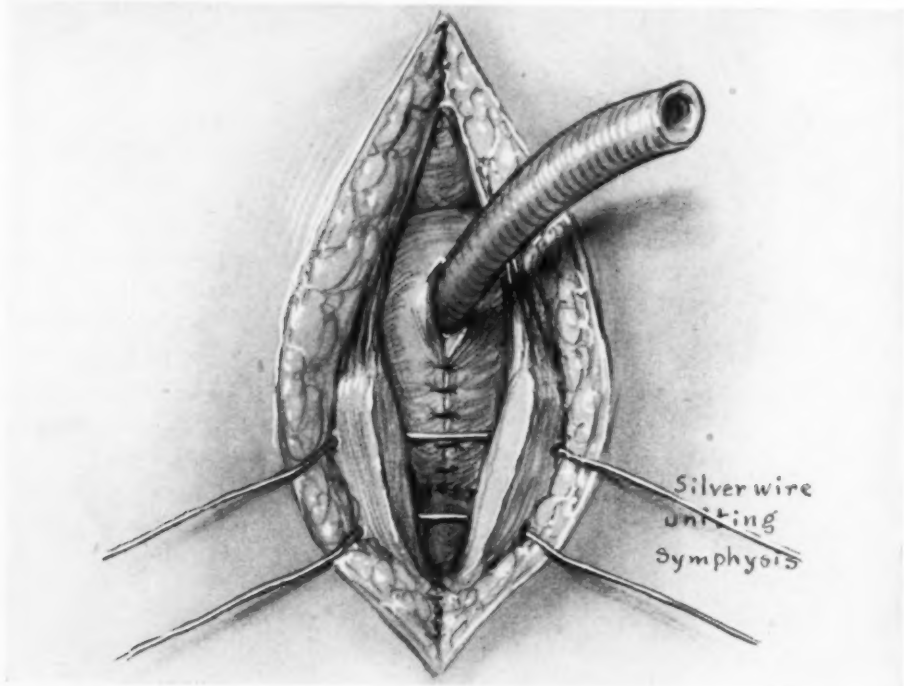

FIG. 6.—Close bladder; rubber drainage tube; two heavy silver wire sutures for closure of pubes.

is put on a Bradford frame, and is kept as immobile as possible during the first week.

The catheter is allowed to remain in for ten days or two weeks, unless

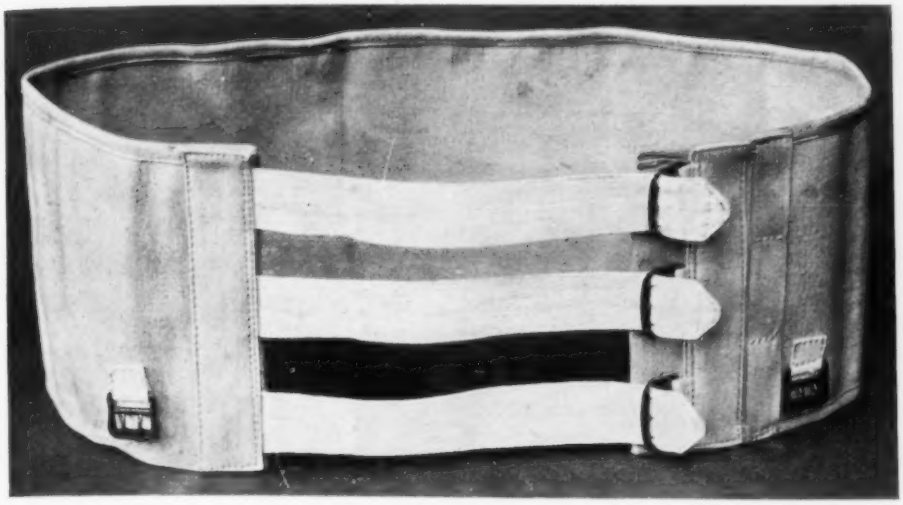

FIG. 7.—Binder to be put on immediately after operation.

it gives trouble. The bladder is irrigated on the second day with warm saline solution. This irrigation is repeated every day.

When the catheter is taken out, a sound is passed every third or fourth day until the wound has healed.

FIG. 8.—Retractor used in separating pubes.

The patient may be up on a back-rest at the end of two weeks and lifted out of bed to a wheel-chair at the end of the third week.

The binder is kept tight all the while. Especial care should be taken of the patient's back; that is, the binder should be loosened and the skin under it cleansed and rubbed with alcohol twice daily.

Report of Cases.—J. Y. M., aged sixty-two, had had pain and frequent micturition for six months, but looked well and had not suffered any loss in weight. The urine contained white and red cells. The prostate was small and very hard. The surface was smooth, and there was no evidence that the growth had broken through the capsule. The vesicles were normal. The diagnosis of carcinoma was based upon the hardness of the gland. Cystoscopic examination showed no invasion of the bladder. X-ray examination did not disclose any metastases to bone.

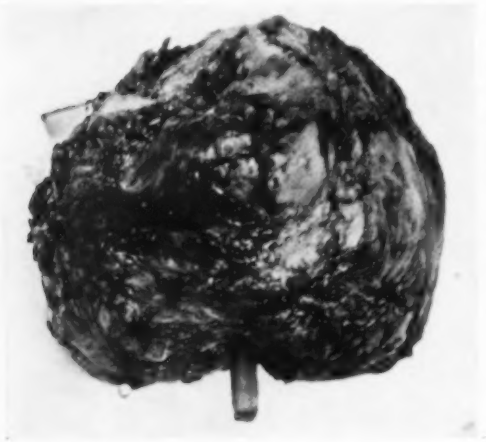

FIG. 9.—Prostate of patient No. 1. Piece of wood placed in urethra.

The operation was carried out as above described. Unfortunately, just at the end, a sharp clamp which had been left on a vessel was found to have pushed through the rectal wall and to have made a wound about half an inch in length. This was sutured but it afterwards broke down, causing a flooding of the wound with fecal matter, which continued for about three weeks.

In spite of the fecal infection the wound healed rapidly. The wire sutures did not hold and were removed. The patient was allowed to be up on his feet at the end of four weeks. He began to void on the thirty-third day. He left the hospital for his home in Florida at the end of the seventh week. At that time he was voiding quite naturally from four to six ounces each time. There was a slight leakage from the suprapubic wound but none from the urethra. A treatment of radium was given as a precautionary measure.

Six months after the operation the patient had gained fifteen pounds; he looked ruddy and healthy, voided normally six ounces at a time; the suprapubic and rectal wounds had entirely closed. Figure 9 shows a photograph of the prostate. On section it was found to be almost completely transformed into a carcinomatous mass.

FIG. 10.—Prostate of patient No. 2.

J. B. P., aged fifty-seven, had had frequent and somewhat painful micturition for one year, and at intervals he had complained of general discomfort and pain in the lower part of the back. He had not lost weight and his general appearance was good. The prostate was hard and firmly fixed, but the surface of the gland was smooth. There were no nodules, and the vesicles were normal. Cystoscopic examination showed that the bladder was not invaded. X-ray showed no metastases to bone.

The operation was more easily done than the one on the first patient. The steps were the same. The patient made an uneventful recovery and went to his home in Tennessee at the end of the fifth week. The suprapubic wound had not entirely closed and there was still some leakage, but he was voiding normally from three to five ounces every three to five hours. There was no leakage by the urethra. Prostate is shown in Figure 10. On the transverse section there is a central area of carcinomatous tissue about the size of a hazel nut.

The patient came back six months after the operation for inspection. There was no evidence of any return. He had gained 20 pounds in weight and looked robust. There was still leakage from the suprapubic wound, but he could hold and void seven ounces. Sounds up to No. 28 were passed and, since some scar tissue was in evidence, he was directed to have this procedure continued every ten days for two or three months.

Patient No. 1 returned for inspection on May 15, 1923. He expressed himself as being perfectly well; has not the slightest evidence of recurrence. Voids urine normally; many times does not have to get up at night.

Patient No. 2 returned June 25, 1923, on account of leakage of suprapubic fistula; in apparent robust health; there is no recurrence. Voids five or six ounces every three or four hours; has no dribbling from urethra.

Both of the above operations were done on my request by Dr. J. M. T. Finney. I beg to thank him very kindly for his services and for valuable suggestions in procedure.

N. B.—Since writing the above, Case II has returned with unmistakable evidence of local recurrence.

THE CONTROL OF HEMORRHAGE FOLLOWING PROSTATECTOMY

By Harold L. Foss, M.D.

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surgeon-in-chief, geisinger memorial hospital

Surgeons will generally agree that controlling bleeding following suprapubic prostatectomy is a step in the operation frequently causing no little concern and one to which considerable attention must be paid in every case. Many devices to facilitate hæmostasis have been suggested from the simple gauze pack to inflatable rubber bags of the Hagner type, certain of which are being used successfully by many surgeons. The simple procedure of

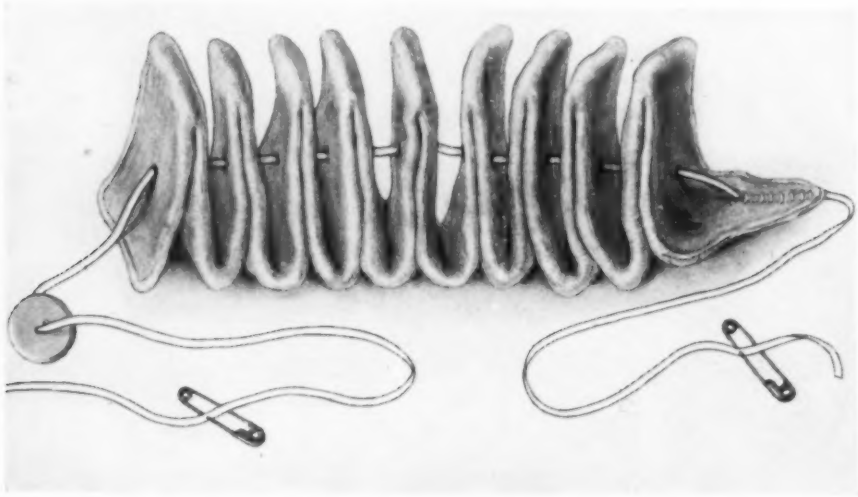

Fig. 1.—Suprapubic prostatic pack.

carefully suturing the prostatic capsule is depended on by men who dislike resorting to mechanical devices for the control of the bladder hemorrhage and with ample time and good exposure such means prove quite satisfactory. The desirability of performing the operation with as great celerity as is compatible with good surgical work and the necessity of operating through a small bladder incision renders careful ligation or suturing often very difficult. Gauze under pressure has always been a popular hæmostatic agent in many operative fields and when packed into the prostatic fossa will, for a time at least, control severe oozing. Its tendency, however, to float away as soon as the bladder fills with urine, renders the effect of the simple pack but a temporary one and so various methods have been evolved of holding the gauze firmly in place until permanent closure of the vessels has taken place.

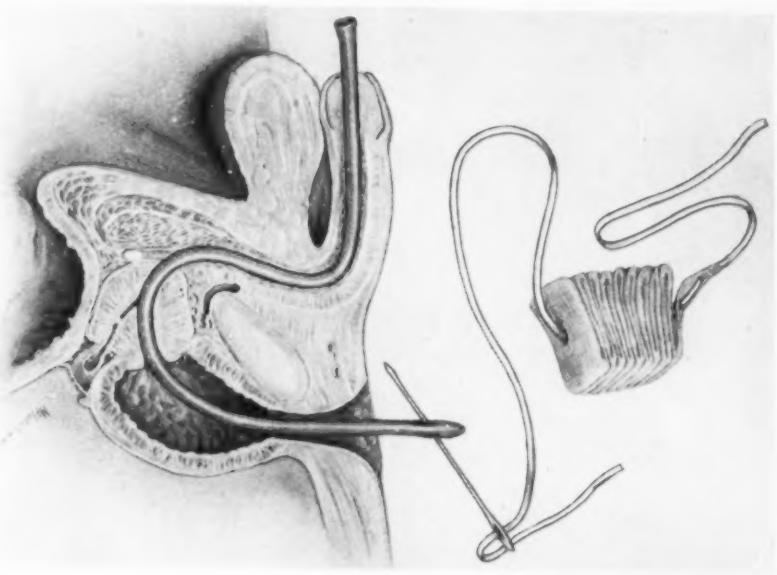

FIG. 2.—Catheter passed. Tape threaded through eye.

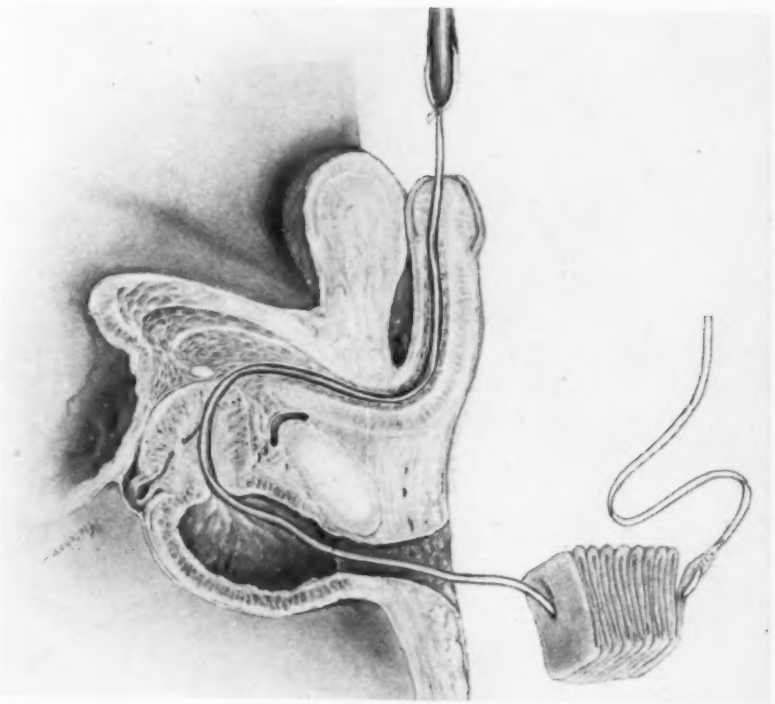

FIG. 3.—Catheter withdrawn, tape brought out through urethra. Pack laid aside while prostatectomy is being performed.

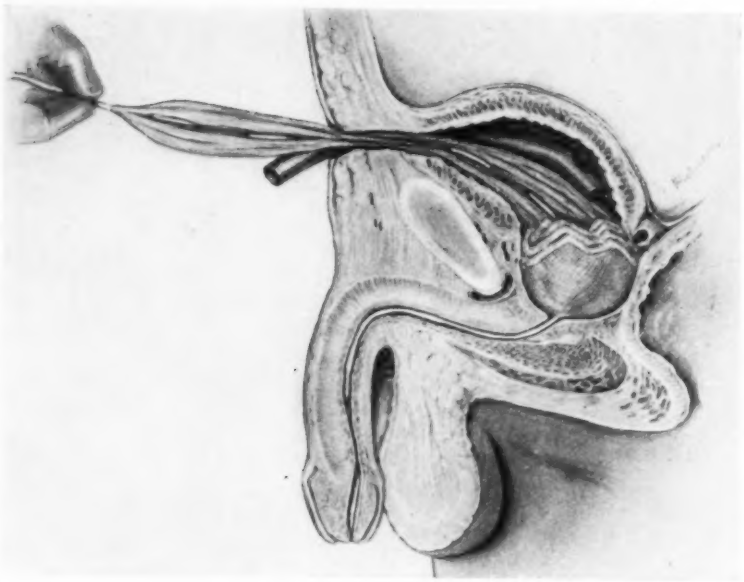

FIG. 5.—Urethral tape cut. Pack being withdrawn.

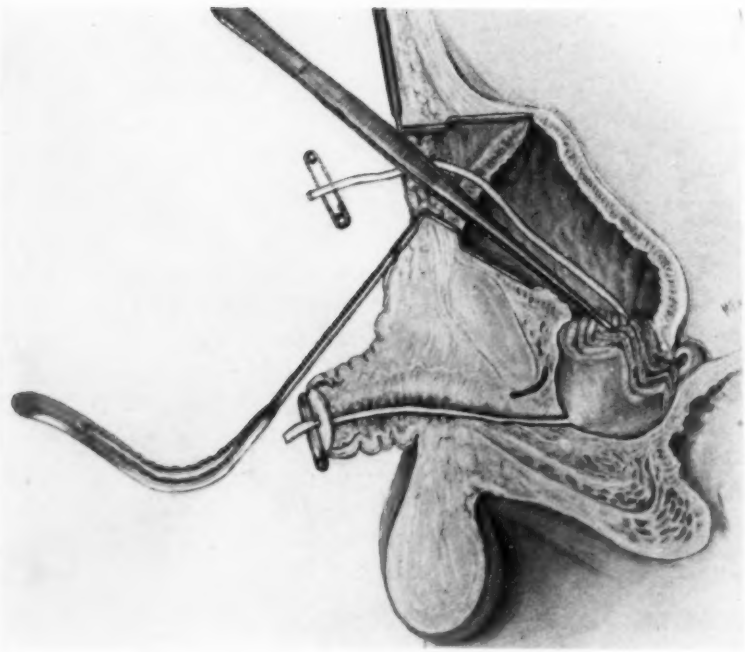

FIG. 4.—Prostatectomy completed. Pack placed in capsule. Tape tightened and secured.

For several years I have been using an accordion plaited gauze pack, through which a tape is threaded in such a manner that when brought out through the urethra and secured against the glans penis, the pack is drawn snugly in the form of a cone into the prostatic cavity and there held firmly in place. A second tape projecting through the suprapubic wound renders the removal of the pack a simple matter, easily and quickly accomplished. With this device hemorrhage is immediately controlled and the bladder rendered absolutely dry before closing.

The pack is constructed of four layers of surgical gauze and unfolded, measures fifty-five inches in length and four inches in breadth. A piece of strong tape is stitched in place, as shown in the accompanying illustration, and following the operation is brought out through the urethra and held snugly in place by means of a safety pin and large button.

Before commencing the operation a catheter, with double eye, is passed into the bladder and on opening the latter the tape is threaded through the eyes and its end withdrawn through the urethra. A hæmostat snapped on the end of the tape prevents it being drawn back into the bladder. The pack itself remains folded in a towel out of the way until the gland is removed, when it is guided into the prostatic cavity by means of long dressing forceps, the urethral tape drawn tightly and the hemorrhage immediately checked. A suprapubic tube is placed in the bladder before the wound is closed. In forty-eight hours the urethral tape is cut and, after a whif of NO_2 has been administered, the pack is withdrawn by means of the suprapubic tape. The tube is then removed, the wound tightly closed with two deep silkworm sutures, and a urethral catheter passed and secured in place.

No doubt similar schemes have occurred to other men and, possibly, many such are in daily use. I had been using the pack in prostatectomies for several years without knowing of it being resorted to elsewhere until the appearance of Doctor Farr's paper in which he describes a similar device. The pack has proven so helpful in my own work that a detailed description of its construction and method of application seems not altogether out of place.

This means of controlling post-operative hemorrhage following prostatectomy has been used routinely in my cases for the past seven years with utmost satisfaction. In no case has there been the slightest hemorrhage and in none evidence of urethral irritation, while the healing of the suprapubic wound has been prompt and satisfactory.

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FRACTURE OF THE ACETABULUM WITH CENTRAL LUXATION OF THE HIP

By Samuel Kleinberg, M.D.
of New York, N. Y.

Fracture of the acetabulum unassociated with extensive injury of the pelvis and pelvic organs is comparatively rare. There are no available statistics to indicate the relative frequency of this injury among fractures. In fact, it is only in recent years that the lesion has been recognized and reported. This is probably so because the clinical picture resembles closely that of other injuries, as for example, contusion of the hip, and can be diagnosed with certainty only from a röntgenogram. Very likely there have been many more cases than are recorded, but, up to 1912, Vaughan was able to collect only twenty-six undoubted cases, and since then, Peet has reported one case and reviewed fourteen others described by various authors. Dr. Royal Whitman in reporting a case of central luxation of the hip mentions that he has seen five others. Compared with fractures and dislocations in other regions this lesion is surely an infrequent one.

The terminology used in this condition is somewhat confusing. It is described by some as a fracture of the acetabulum, by others, as central luxation of the hip, central or intrapelvic displacement or dislocation of the femoral head. There are actually two distinct lesions, a fracture of the acetabulum and an inward displacement of the femoral head. Both lesions vary in degree. The extent of the displacement of the femoral head depends upon the severity of the fracture of the floor of the acetabulum, and the distance to which the fragments are driven inward. The injury results from a force acting upon the great trochanter. The head of the femur driven inward shatters the acetabulum, forces its fragments into the pelvis and thus becomes dislocated. The primary lesion is, therefore, a fracture of the acetabulum. The secondary resultant condition is the displacement or dislocation of the femoral head. The latter, however, is responsible for the ultimate disability and it is to the correction of this, the dislocation, that treatment need be directed. The fracture of the acetabulum, except in very rare cases, cannot be treated because of the inaccessibility of the parts. I am at this moment excluding from consideration those cases in which there is an injury of the pelvic structures by the fragments of the acetabulum requiring intrapelvic exploration. At such an operation manipulation of the fragments into proper alignment may be possible. Usually in an injury of this kind, which is severe and dangerous, the condition of the pelvic organs is so grave and the general condition of the patient so poor that the associated injury of the hip must necessarily be overlooked for a long time. As in fractures of other bones, so in acetabular fractures, the fragments may not be displaced at all; or they may

be moderately disarranged and driven inward without dislocation of the femoral head, or the fragments may be pushed inward considerably and the femoral head dislocated into the pelvis. Ochsner divides this injury accordingly into three distinct types: (1) a fissured fracture with no displacement; (2) multiple fracture and inbending of the acetabulum; and (3) complete dislocation of the femur through a badly shattered acetabulum—central dislocation of the hip. It would appear to be best, therefore, to describe these cases under the title of fracture of the acetabulum with or without central luxation of the hip.

FIG. 1.—Case 1. J. C. Fracture of the acetabulum. Inward displacement of the middle two-fourths of the floor of the acetabulum. Femoral head not dislocated.

Two factors militate against the more effective control of this lesion. One is that at times the injury results in such severe shock or extensive and dangerous involvement of the bladder, intestines, blood-vessels or other pelvic organs that although, one may be aware of the lesion in the hip, it is impossible to apply treatment for its relief until many weeks afterward. The other is failure to recognize the nature of the lesion. The fact that in many of the reported cases the patients were not seen until several weeks and even months after the injury attests to the frequency of the latter unfortunate occurrence. After such a lapse of time it is difficult to apply curative measures which would be easily carried out immediately after the injury.

There are no distinctive or pathognomonic features in the clinical appearance of the patient which may assist one to make a diagnosis, but there are several very suggestive findings. The most important of these is a sunken appearance of the great trochanter (Fig. 3). In the ordinary congenital or acquired dislocation of the hip the great trochanter is abnormally prominent. In fractures of the upper extremity of the femur or of the pelvic bones, except that of the acetabulum, the normal prominence of the trochanter remains. In this injury, however, there is a flattening of the hip which is comparable to that of the shoulder in subglenoid or subcoracoid dislocations. Because of the

naturally bulging and fleshy appearance of the hip, slight flattening may not be evident; but when recognized, it forms an important guide to the diagnosis of central dislocation of the hip. A direct blow over the hip may, of course, cause a variety of traumatic lesions in and about the hip, but in a case in which there is a history of such an occurrence and none of the characteristic signs of other lesions, such as dorsal dislocations, fractures of the neck of the femur, fractures of the great trochanter or shaft of the femur, fractures of the ilium or ischium, separation of the symphysis pubis and so forth, fracture of the acetabulum with central dislocation of the hip should be thought of. Persistent pain and disability in the absence of evidence pointing to such lesions as have just been enumerated, should lead one to suspect a central luxation of the hip. Simple contusion of the hip, even if very extensive, rarely results in prolonged pain and disability.

FIG. 2.—Case II. M. C. Fracture of the acetabulum. Inward displacement of acetabular fragments and head of femur. Great trochanter is in contact with the ilium.

As a matter of fact, now-a-days, in a large city and in well equipped rural institutions the diagnosis would rarely be in doubt, for, in any extensive injury to the hip, an X-ray study would be routine. It is, however, worth while to emphasize the fact that a history of a blow over the hip, persistent pain, disability and flattening of the external surface of the hip jointly constitute strong evidence of a fracture of the acetabulum with central luxation of the hip. It is important to remember this clinical picture because there are still sections of the country which are lacking in complete modern X-ray equipment. Even in the city one is at times misled by poor röntgenograms. It has latterly become the practice among many physicians to have X-ray apparatus in their offices with little training in the art of X-ray photography. I have seen many pictures taken by inexpert men which were so poor and blurred that it was difficult to identify the gross outline of bones, much less the intricate structures

of the hip joint. Many general practitioners desiring to give their patients full service do their own X-ray work, but unless the plates are clear and the physicians have trained themselves to read them, they do not render their patients a service, but, on the contrary, may do harm because they do not obtain the proper information from the plates. I emphasize this point because I have had a goodly number of such pictures brought to me and am convinced that it is a pernicious practice which should be discouraged, especially in large medical centres where the best workmanship and talent are available.

FIG. 3.—Case III. M. C. Fracture of the left acetabulum and central dislocation of the hip. Note sunken appearance of left great trochanter, flexion and adduction contraction of the hip and atrophy of the left lower limb.

The object of treatment is to reduce the dislocation. As most cases are seen some time after the injury, proper alignment of the broken fragments is out of the question. In the rare cases which are seen early some attempt at outward displacement of the acetabular fragments may be made. In females by introducing the hand into the vagina, one may be able to push the fragments into place. Doctor Grausman, of New York, related to me an interesting experience. He was called to see a case of fracture of the acetabulum in which there was a comminuted fracture with inward displacement of the fragments and of the femoral head. The patient was given a general anæsthetic. Doctor Grausman then stretched the rectal sphincter so that he was able to introduce his hand into the rectum and, as the fracture was on the left side, he reached toward the acetabulum, pushed the fragments outward and reduced the dislocation of the femoral head. In the average case, seen weeks after the accident, the fracture is healed and the pain and disability are due to the dislocation. Most surgeons have used longitudinal and lateral traction in the treatment of this dislocation and in many cases satisfactorily. Dr. Royal Whitman in his case successfully applied the abduction method. Using the great trochanter, which is usually in contact with the ilium, as a fulcrum and the thigh as a long lever he forced the femoral head out of the pelvis. His was

a case of long standing, and by means of the abduction method he was enabled to use the strong force necessary to dislodge the head of the femur. This method appealed to me as a logical procedure and superior to and more easily and accurately applied than the complicated and less certain method of longitudinal and lateral traction. Lateral traction in the thigh for hip conditions, such as fracture of the neck of the femur, has always appeared to me to be a very uncertain process, because of the technical difficulty of using any great amount of force accurately. In two of my cases in which the abduction method was used the anatomical and functional results were good.

FIG. 4.—Case III. M. C. Note marked inward displacement of the acetabular fragments. Central luxation of the femoral head. Great trochanter abnormally near the ilium and the lesser trochanter near the ischium. Large mass of bone in the interval between the ilium and great trochanter.

CASE REPORTS

CASE I.—J. C., male, thirty-seven years old. This patient was seen in Doctor Whitman's clinic at the Hospital for Ruptured and Crippled and I am indebted to Dr. Arthur Krida for the details of the history and examination. The patient applied for treatment on April 24, 1923, complaining of disability in the right hip. Four weeks previously he fell from a truck, a distance of about 3 feet, striking the shaft with the full force of his body against the hip and had to be lifted out. He has since been getting about, but with pain from which to date he has had no relief. He walked with the aid of a cane and with a marked limp on the right side. All motions of the right hip were very painful. The limb was held slightly flexed and adducted at the hip. There was marked tenderness of the hip. An antero-posterior X-ray picture, Fig. 1, showed a fracture of the acetabulum. The middle two-fourths of the floor of the acetabulum were displaced inward about an eighth of an inch. There was no appreciable displacement of the femoral head. Correction of the deformity was advised but the patient refused to submit to treatment.

CASE II.—M. R., male, thirty-two years old. He applied for treatment in the out-patient department of the Hospital for Ruptured and Crippled and was admitted January 13, 1922 to Doctor Whitman's service, where he came under my care. The history showed that 5 months previously he fell from an ice-wagon striking on the right buttock and outer side of the hip. He was unable to rise and was carried home. A diagnosis of contusion of the hip was made. He remained in bed for about 6 weeks because of pain in the limb. He then began to walk, but only with the aid of a cane, and with great discomfort and difficulty. The pain and disability persisted and he was relieved only by sitting down.

Examination showed that the man walked with a marked limp on the right

side, the body inclined forward and the right hip flexed. The trochanter was not prominent and not elevated. Extension of the hip was limited to 130 degrees, that is, 50 degrees short of the normal. Flexion was fairly free but all the other motions were restricted and painful. In the line of deformity RA measured 28¼ inches and LA 29 inches. There was marked atrophy of the right thigh and slight atrophy of the right leg. An X-ray picture, Fig. 2, showed a fracture of the acetabulum with inward displacement of the acetabular fragment, and inward dislocation of the femoral head so that the trochanter was in contact with the ilium. There was also a fracture of the right pubic bone near its junction with the ischium. The rest of the pelvis was apparently normal.

Operation January 16, 1922. Under a general anæsthetic the right limb was forcibly stretched into extension and abduction until the deformity was entirely corrected and a plaster-of-Paris spica bandage was applied. A subsequent X-ray picture showed a marked improvement in the relation of the femur to the pelvis. About two weeks later I made a note to the effect that the patient had no pain and walked without assistance. The manipulative correction of the malposition of the femoral head and the change in the attitude of the limb resulted in an improved as well as painless function.

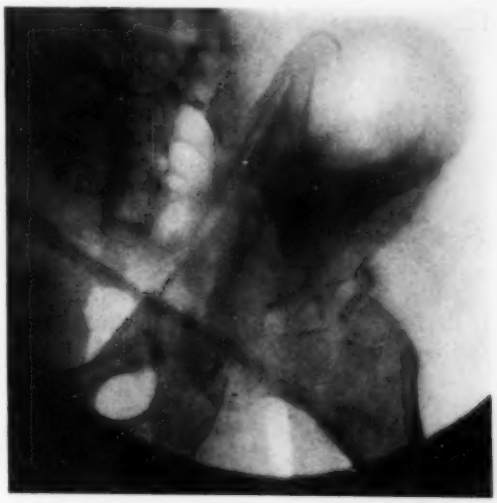

FIG. 5.—Case III. M. C. Appearance of left hip after stretching and reduction of the deformity. The limb is an abduction and the femoral head and the trochanters are in their normal positions.

CASE III.—Mary C., thirty-five years old, was struck by an automobile on August 16, 1922. She was dragged along the ground for a short distance, sustaining an injury of the left hip. On account of severe and persistent pain in the hip she remained in bed for about 5 months. She received no treatment except baking and massage, and, although an X-ray picture was taken, the nature of the injury was not diagnosed. Five months after the injury she began to walk with the aid of a cane. She had a marked limp on the left side and severe disabling pain. One month later I was consulted and she was admitted to the Hospital for Ruptured and Crippled.

Examination showed that she was thin, pale and in poor general condition. Showing the effects of prolonged suffering. Lying in bed the left limb was flexed and adducted at the hip. Turning in bed and handling of the limb was very painful. She was able to walk, but only with a cane and with a marked limp, pain and great effort. The left hip was flexed to 150 degrees and adducted 15 degrees. There was loss of the usual prominence of the great trochanter and a sunken appearance in this region which was especially noticeable in the upright posture (Fig. 3). Flexion of the hip was limited to 100 degrees. Abduction was entirely restricted. Rotation was limited and painful. There was very marked tenderness of the great trochanter. The right limb measured 29 and ⅛ inches from the anterior superior iliac spine to the internal malleolus and the left limb 28 and ⅝ inches. The circumference of the right thigh was 18 and ⅛ inches and that of the left thigh was 16 and ¾ inches. Vaginal examination revealed a large

bony mass on the left side which was evidently the healed, inwardly displaced fragments of the acetabular floor. Movement of the femur was not transmitted to the bony mass in the vagina so that the femoral head had not penetrated into the pelvic cavity.

An X-ray picture, Fig. 4, showed a healed fracture of the acetabulum. The united fragments were displaced inward and formed a large bulging mass invading the pelvic cavity. The head of the femur was displaced inward so that the great trochanter was near the ilium and the lesser trochanter appeared to touch the ischium. There was a large fragment of bone between the ilium and great trochanter. The shaft of the femur was markedly adducted.

The immediate indication in the way of treatment was correction of the adduction and flexion deformity. If possible, the inward displacement of the femoral head was to be reduced. As the patient was almost completely disabled and was suffering much pain, treatment was imperative. She was, therefore, urged to submit to operation. Correction by forcible manipulation was to be tried first. If this was not successful, an open operation on the hip or an osteotomy of the femur was to be performed. On February 9, 1923 the patient was given a gas-oxygen anæsthetic. The right limb was held firmly flexed at the hip and the left limb forcibly extended. Though great force was used the flexion deformity could not be corrected. The left limb was then forcibly abducted and with a crunching noise on the outer side and a tearing sound on the inner side of the hip, the limb was brought out into 35 degrees of abduction and complete extension. In this position a plaster-of-Paris spica bandage was applied. An X-ray picture (Fig. 5) taken sometime afterward showed not only an improved attitude of the limb, but also that the head of the femur had been brought out into its normal position, that is, the dislocation was reduced. The mass of bone between the great trochanter and the ilium had been crushed.

A few days after the operation the patient had no pain in the hip or limb and 6 weeks later she was discharged from the hospital, still wearing a short plaster spica, but with the deformity entirely corrected and no pain in the extremity. This case is interesting in demonstrating the effectiveness of the abduction method in reducing an old central dislocation of the hip. It seems to me that it would have been futile to have attempted to obtain any results by traction either longitudinal or lateral or both.

From a review of the cases reported in the literature and my own experience, the following observations may be emphasized: Fracture of the acetabulum with or without central luxation of the femoral head and not part of an extensive injury of the pelvis is a rare lesion. As there is a fracture of the acetabulum and a dislocation of the hip, the lesion should be described by the long, perhaps cumbersome, but descriptive title of fracture of the acetabulum with or without, as the case may be, central luxation of the femoral head. The history of a blow over the great trochanter, marked tenderness of the hip and a flat or sunken appearance of the great trochanter should suggest the likelihood of a fracture of the acetabulum with central luxation of the femoral head. An X-ray picture should be taken as soon after the injury as possible. This, if clear, will indicate the exact nature of the lesion. The ideal treatment is immediate reduction of the dislocation and immobilization in abduction. The reduction may be accomplished by the abduction method, which permits the effective use of the thigh as a strong lever over the great trochanter as the fulcrum.

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SCLERODERMA WITH GANGRENE OF FINGERS

REPORT OF TWO CASES

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Extensive research into the literature shows that although the causes of gangrene, especially of the extremities, have been described very thoroughly, the two cases to be reported demonstrate another etiologic factor apparently not mentioned. This is the mechanical compression of the vessels caused by too tight-fitting skin, the etiology in these cases being scleroderma.

CASE REPORTS

Case I.—S. G., age, twenty, male Russian. Five years ago first noted trouble in fingers of right hand. A few weeks later in the right elbow. Eight months ago, two fingers of the right hand and two fingers of the left hand simultaneously. At the same time he began to complain of pain in the index finger of the left hand, this terminated with gangrene and the index finger was operated on. Shortly afterward had middle finger amputated and since then the fourth finger of the left hand was affected in the same way. Pulsation, strong. Wassermann negative.

Briefly stated several important facts are brought out in this short history. His age, his nationality, simultaneous affection of right and left hand, swiftly spreading gangrene uncontrolled by amputations, pulsation strong and Wassermann negative. The strong pulsation at once ruled out Raynaud's disease. He was admitted to the Peoples Hospital, December, 1917. Having had a short time previously the right middle finger amputated at the second joint elsewhere. As the gangrene kept increasing further amputations were recommended.

Examinations showed that locally the tips of all fingers were necrotic, but most of the lesions were in the right hand, which was swollen and discolored. The middle finger had been amputated at the second joint, the bone was protruding from the distal portion and the fleshy part was gangrenous and swollen. He also had necrotic (trophic) ulcers over the head of the metacarpal bones and over the olecranon processes. Generally he presented all the lesions of an advanced general scleroderma; tight dry skin over the face, drawn features, considerable difficulty in opening his mouth, his eyelids drawn, the skin over his chest tight and drawn, likewise the skin over his lower extremities. His Wassermann was negative. The remaining stump was amputated and he was given hypodermic injections of pituitrin. This with local applications of chlorazene paste checked the tendency of the gangrene to spread. Not only did the gangrene in all the finger tips clear up but also the ulcers over the knuckles and at the elbows. At present although there has been a considerable improvement in both his general and local condition, still there has developed a more or less permanent flexion of the fingers of his left hand resulting in a typical sclerodactylia.

Case II.—Mrs. B. D., age twenty-eight, Russian, seen first, November 27, 1921, representing gangrene of the tips of all fingers. In addition to this a general examination revealed an extensive scleroderma, most marked in the face. The mouth could be opened with difficulty and even the eyelids were considerably affected. The skin over the chest, arms, legs and feet was so tight that it could not be lifted into folds. Pituitrin 1 c.c. hypodermically once a day, for about two

weeks, caused the gangrene on the finger tips to disappear and also resulted in a relaxation to a marked degree of the entire cutaneous surface. This was most marked in the face and especially about the mouth. The improvement (not cure) in each case has been more or less permanent, treatment being continued for a period of one or two weeks each winter.

Besides the surgical gangrene and the skin condition of scleroderma, there were concomitant signs of endocrinological disturbance, for a study of which these patients were referred to Dr. Hyman Goldstein, who has made the following report:

Observations on Case I.—S. G. Weight, 98 pounds, height, 62 inches, pulse 96, systolic blood-pressure 100, diastolic 50. Body measurements and female hair distribution indicate adrenal domination in growth. His small tapering head and facial expression is like a marasmic child grown to adolescence. He has a small, narrow palatal arch, small incisors and canines with four artificial teeth. The skin of the following regions, bridge of the nose, forehead, molar regions, about the mouth, chest, scapulæ, lower abdominal region, extensor surfaces of elbows and the hands, is rigid, glossy and goose-like. These areas show also bronze-like discoloration with positive Sergent's reaction. There is also marked flexor contracture of the left little, index and ring fingers. These findings and history of the case with such marked circulatory and skin dystrophic condition and positive Sergent's line with marked asthenia is evidence of a hypoplastic dyscrinism of hypoadrenal predominance, dyspituitarism and hypothyroidism.

Observation on Case II.—Mrs. B. D. Weight, 143 pounds, height, 63 inches, pulse 120, systolic blood pressure 100 and diastolic 45. Lungs normal. The heart is enlarged to the right, mitral presystolic murmur, muffled first apex sound and subclavian hum. Hair is scanty on scalp and outer third of eyebrows. Pupils are markedly dilated and react sluggishly to light and accommodation; vision is markedly myopic. Pharyngeal, superficial and deep reflexes exaggerated. Hands are cold and skin hard and dry, fingers and nails show trophic changes of sclerodermal type. Neck reveals a moderate size isthmus-thyroidæ undoubtedly of colloidal type. The skin is indurated and thickened showing marked trophic changes particularly in the tufts of the fingers, cracked at the phalangeal joints dorsal surface. Rough and rigid about forehead, chest, back, extremities, nose and lips. Difficult to open mouth widely. Her mentality is sluggish and she suffers from lapses of memory. At present she has a compensatory parenchymatous hyperthyroidism, which in these cases often alternates with periods of hypothyroidism and an hypoadrenia dyspituitarism and dysovarism of the hypo-functioning type.

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THE DISABILITIES OF THE HAND AND THEIR PHYSIOLOGICAL TREATMENT*

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Anatomical and Physiological Considerations.—The hand is such a complicated organ that a knowledge of its structure and function is essential to the successful treatment of the individual lesions. In the treatment we must not lose sight of the fact that the hand, in addition to being a marvelous mechanism

Fig. 1A.—Four months after an infectious arthritis of the carpus. A stiff useless hand. Note the position of wrist and fingers fixed in extension.

capable of the most delicate and intricate movements, is also a highly specialized sense organ.

The Position of Rest.—(Physiological balance.) In the mechanism of animal life it is a universal law that periods of activity are followed by periods of rest. The normal physiological position of the hand is simply an expression of the state of rest of the muscles, joints, nerves and vessels, the balance being maintained by the resting tone of the muscles. If you examine your own hand as it hangs by your side you will find that the arm is slightly pronated, the wrist dorsi-flexed, the palm hollowed and the fingers bent toward the palm. The little finger is flexed the most, then the ring next, then the middle, the index is

* Read before the American Surgical Association, June 2, 1923.

relatively extended when compared with the others. The palm is hollowed from side to side as well as in its length.

If the hand is to be rendered passive by a splint, this splint must fulfil the following conditions: It must maintain the hand in the physiological position of rest, preserve the normal arches of the hand and allow suitable motion.

The Arches of the Hand.—The hand is made up of three main arches, one longitudinal and two transverse. The longitudinal arch has as its bony arch the moderate palmar curve of the metacarpals and the slight curve of the carpus. The arch is accentuated by the disposition of the fascia in the hollow of the hand and by the fact that in the position of rest the fingers are slightly flexed.

FIG. 1B.—X-ray showing atrophy of destruction.

Of the two transverse arches the proximal or wrist arch is a deep, trough-like structure formed by the carpal bones. This trough carries the flexor tendons, its roof is formed by the annular ligament, its radial wall by the trapezium and the semilunar, the ulnar wall by the unciform and pisaform. The tendons of the long muscles which flex the fingers use the hook of the unciform as the ulnar fulcrum and the trapezium as the radial fulcrum, the greatest force coming against the trapezium. Any relaxation or flattening of the arch weakens these lateral fulcrums and force the tendons to work at a great mechanical disadvantage.

The distal transverse arch has a gentle palmar curve and is formed by the heads of the metacarpals. It is a broader arch than the carpal and is increased

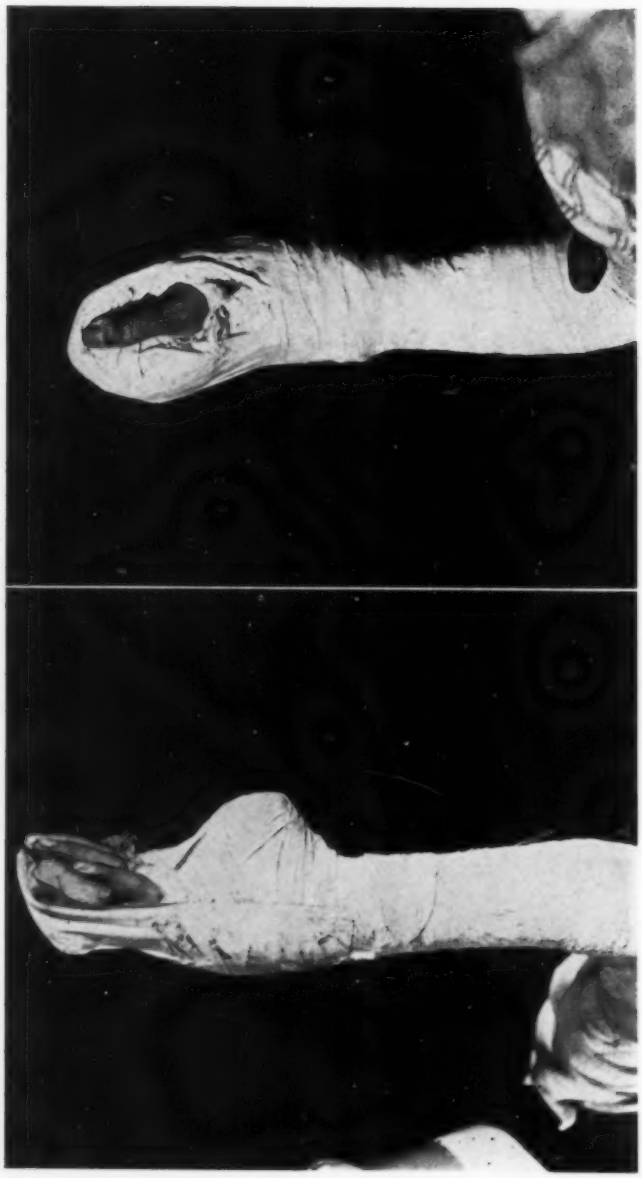

FIG. 1C.—Shows the first stage in the treatment of stiffness and deformity of the wrist. The placing of hand and wrist in the position of rest. Later to be followed by wedging according to the Dickson technic, etc., for the deformity of the fingers.

in depth when the hand is used, due to the flexibility palmward of the fourth and fifth metacarpals.

The arches of the hand are not to be considered as mere bony frameworks, but as living, functionating, structures composed of bones, joints and ligaments, the functional integrity of the whole depending on a healthy musculature. The intrinsic muscles of the hand play a most important part in maintaining this integrity. In extension the fingers spread out like a fan, in flexion they converge toward the palm, the middle finger alone flexing in the line of its metacarpals. The tip of the thumb comes in contact with the other fingers, but faces in an opposite direction. This coördinate converging movement is absolutely essential to the delicate use of the hand and is impossible unless the carpal arch is preserved. In examining cases of paralysis of the interossei from nerve injury the movements of adduction and abduction of the fingers during flexion and extension have frequently been mistaken for true interosseous movements. The extrinsic extensors can splay the fingers, the long flexors converge them, but no muscle group other than the interossei can move the middle finger from side to side in the plane of the extended hand.

FIG. 1D.—Ten months later. The result of treatment, a strong powerful grasp.

The Thumb and Its Relation to the Hand.—The thumb is the most important digit of the hand, its functional value exceeding that of the four other fingers. The capsule and synovial cavity of the first carpo-metocarpal joint are distinct from the other carpo-metacarpal articulations, and there is no interosseous ligament binding the thumb metacarpal to the index. The saddle-shaped articular facet of the trapezium allows an unusual freedom of motion. Any muscle which acts upon the joint may produce very unusual movements. This is seen in the "Trick movements of the Thumb" in certain cases of paralysis.

The proper functioning of the thumb is directly dependent on the integrity

of the arches of the hand. Any weakness or damage to these arches means an impairment in strength, mobility and fineness of movement.

From a surgical standpoint we can consider the basal element of the first digit as a phalanx. It possesses many of the functional and developmental characteristics of the phalanges, the most noteworthy function being its freedom of motion. Of all the metacarpals it shows the most varied mobility, next comes the fifth, then the fourth, the index possesses but little mobility, while the middle is the most fixed of all. To procure the best functional results

FIG. 2.—Goldwait's flat hand strap.

in atypical amputations and in certain disabilities following trauma these relative mobilities must be borne in mind. Huguier's operation and similar operations are based on the mobility of the first metacarpus; while on the other hand, Baldwin's operation for paralysis of the intrinsic muscle of the thumb, is based on the abolition of this mobility by an arthrodisis of the first carpo-metacarpal joint.

Note that the thumb lies at least in a plane almost at right angles to the other fingers. Its palmar surface faces across the hand with a slight axial rotation toward the palmar surface of the index finger. Try and hold your own thumb in the same plane as the other fingers and see how fatiguing it is, yet we often see a damaged thumb splinted in this unphysiological manner. In fractures of the phalanges the axial rotation must be remembered. Perthes, in his operations for plastic substitution of the thumb, reproduces this axial rotation in the transplanted metacarpal by osteotomy. In the position of grasp

the basal metacarpal of the first digit makes an angle of 60° with the index, this is the functioning position for almost all purposes.

Skin Joints, their Function and Respect Due Them.—The crease lines of the palm and fingers are nicely adjusted stasis planes designed to permit the greatest freedom of flexion to the joints of the hand. Great disability can be inflicted on the fingers and tendons by a thoughtless interference with these planes. To damage existing crease lines is bad enough, to create new stasis lines at right angles to the normal creases may inflict a serious functional handicap. Such a condition is often encountered in the fingers. In the excision of scar tissue, in atypical amputations and in the transplantation of skin flaps precautions should be taken to have the suture line follow as far as possible the normal crease lines.

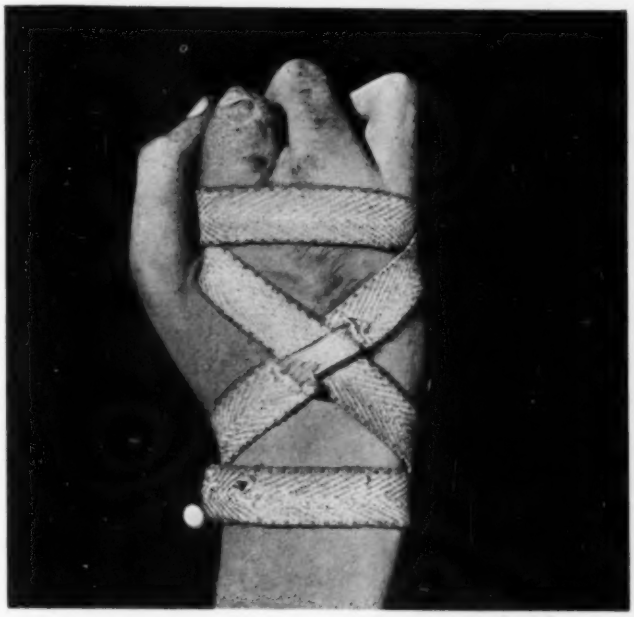

FIG. 3.—A simple figure-of-eight strap with a palmar pad to support the metacarpal arch, used in cases where the removal or damage of metacarpus has led to a weak and painful hand.

The Preservation of Tendon Slings and the Gliding Mechanism of the Tendon Sheaths.—The function of the slings is to hold the tendon in place as it passes over the joint. We have mentioned the disabilities which arise from interference with the normal stasis lines, but these are trivial when compared with those that follow the thoughtless slitting up of a tendon sheath. If it is necessary to incise a sheath, the tendon slings should be saved by skipping them.

Treatment.—The physiological treatment of the disabilities of the hand is based on a few simple principles, and these can be applied to disabilities which follow sprains, dislocations, fractures, injuries to tendons, injuries to nerves and to the innumerable lesions which follow in the wake of a cellulitis and trauma.

The outstanding disabilities following these varied pathological conditions are loss of substance, skin contractures, painful stumps, joint stiffness, adherent tendons, bad functional position, drop wrist, flat hand, claw hand, damaged arches, loss of grasping power, ischæmic paralysis.

The functional and anatomical relationships of the structures of the hand

are so intimate that it is rare to have but one structure involved in a disability. As a rule, we have to deal with combinations rather than with individual lesions. The most usual associations encountered is structural damage, adherent tendons and joint stiffness.

In the operative correction it is obvious that deformity and joint stiffness must be overcome before any serious tendon reconstruction can be undertaken.

Treatment of Stiffness and Deformity of the Wrist.—We will take it for granted that the lesions under discussion have received a thorough course of

FIG. 4.—Typical case of flat hand with hyperextended metacarpo-phalangeal joints. This condition is extremely difficult to treat.

physiotherapy and that the disability has failed to respond or that the limit of improvement by these means has been reached. We will omit the treatment of Colles' fracture and the treatment of fracture and dislocation of the carpal bones with the comment that any disability of the hand or wrist (except Colles' fracture in the first stage of treatment) should be placed in the position of rest.

Always try for a mobile wrist, if failure is inevitable or if ankylosis is thought advisable place the wrist at 30° dorsi-flexion. With free pronation and supination this makes a strong, useful wrist. (Figs. 1—A, B, C, D.) When free rotation is impaired by involvement of the inferior radio-ulnar joint it can be restored by the removal of a small portion of the ulna (Cotton's operation).

Treatment of Flat or Weak Hand.—In the simple cases arising from weakness and relaxation, much can be done by suitable muscular exercises. In the cases where there is a yielding of the lateral bony supports of the proximal carpal arch, giving rise to weakness and pain, excellent results are obtained by the use of Goldwait's flat hand strap. The strap to be worn until the muscles

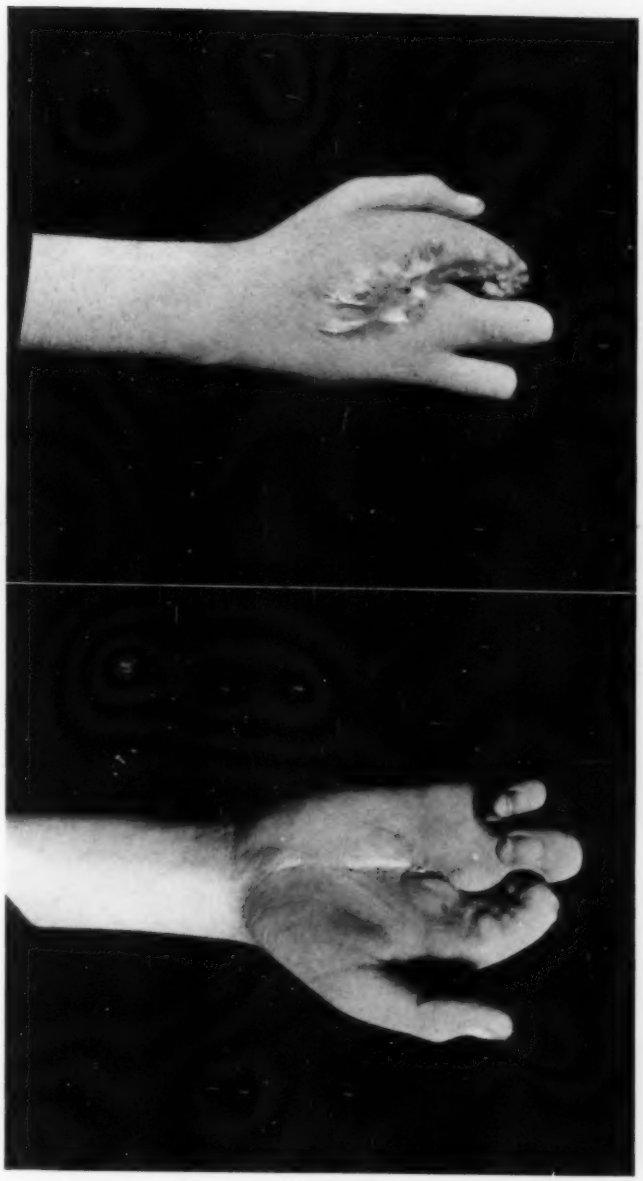

FIG. 5A.—A stiff useless clawed right hand, due to damage to the transverse metacarpal arch and partial paralysis of the small muscles of the hand. Condition three months after injury.

and ligaments have regained their tone. (Fig. 2.) In the severe cases, with bony displacement, manipulation under an anæsthetic plus temporary fixation in plaster may be required. In the cases where a weak and painful hand has developed after the removal of a metacarpus, or some portion of it, the author has employed a figure-of-eight strap with a supporting palmar pad or a suitable glove reaching to the fingers, which is reinforced to support the transverse metacarpal arch. Heavy manual work involving the use of this portion of the hand can then be successfully undertaken. (Fig. 3.)

Treatment of Fractures of the Metacarpals.—The most usual deformity is a shortening and dorsal bowing of the shaft, plus a depression of the knuckle.

FIG. 5B.—Anatomical result obtained by Stiles' operation.

The integrity of the longitudinal arch being impaired, limitation of flexion of the metacarpo-phalangeal joints results. Such fractures are best treated by traction with a dorsal pad over the shaft and a supporting palmar pad under the head.

We have seen neglected cases of this type simulate closely the claw-hand that occurs in paralysis of the intrinsic muscles of the hand. The lumbricales and interossei arise from the deep flexor tendons and wind around the proximal phalanx to be inserted into the common dorsal extensor expansion. Their functions are to fix and flex the metacarpo-phalangeal joints and extend the first and second phalangeal joints. It can be readily seen that in fractures with displacement these tiny muscles, in addition to being injured by the fracture, may be placed at an immense mechanical disadvantage. If they are not protected the stronger common extensor will hyperextend the knuckle and the

common flexor will roll up the second and third phalanges. The static condition persisting an adaptive shortening develops which in turn leads to fibrotic clawing of the hand. This condition is extremely resistant to treatment (Fig. 4).

Treatment of Clawing.—The clawing following the paralysis of the small muscles of the hand is a severe disability. If it fails to respond to treatment a useful hand can be obtained by Stiles' operation. (Figs. 5—A, B, C.) In this operation both halves of the sublimis tendon, where it splits to let the profundus pass through, are detached from their insertions and passed to the

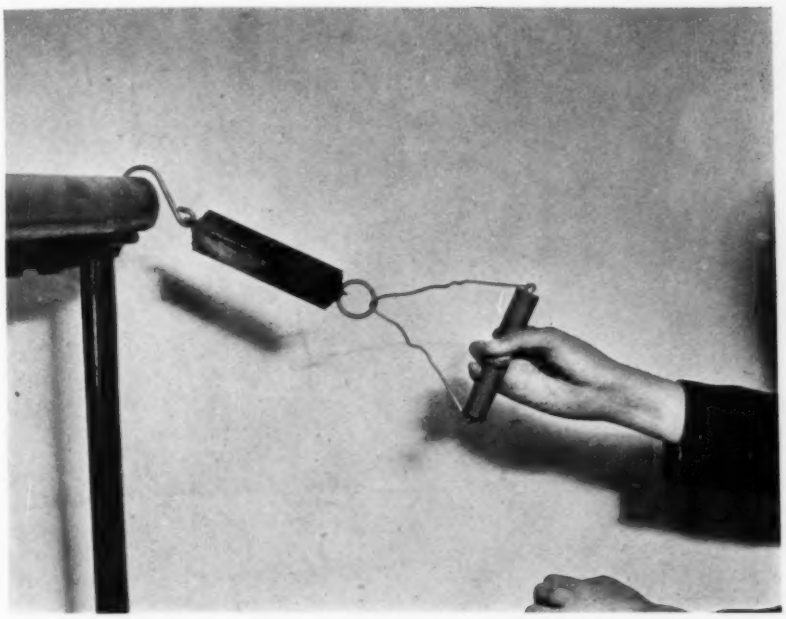

FIG. 5C.—Functional result three months after Stiles' operation. The patient has returned to work. The hand was treated by plastic repair, and traction of the fingers by Baldwin's splint. The maximum improvement having been obtained by these means Stiles' operation was then performed.

back of the finger, to be sutured into the extensor communis tendon distal to the knuckle, thus making an extensor for the interphalangeal joints.

A second method consists in performing an arthrodesis of the metacarpophalangeal joints and placing them in a position of slight flexion.

Thumb.—One of the commonest disabilities of the thumb is the adduction-extension deformity. The most frequent causes of this disability are the skin cicatrices and the fibrous contractures of the deep structures of the first interosseous space that follow burns, trauma and infection; occasionally it is encountered after fractures of the first and second metacarpals; it is the usual sequel to paralysis of the thenar muscles. This deformity is most frequently met with in those cases which have undergone prolonged immobilization in flat board-like splints.

If corrective splinting and physiotherapy fail much can be done by conservative plastic work. In the treatment of paralysis of the thenar muscles we have the choice of two procedures—an arthrodesis of the carpo-metacarpal joint or tendon substitution. An example of the former being Baldwin's operation, of the latter, operations of the type of Steindler's or Ney's.

Baldwin's operation for flat adducted thumb deformity is an arthrodesis at the basal thumb joint to procure a short fibrous union in the functioning position. A short anterior incision is made into the basal joint, the thumb is twisted into the fullest internal rotation, complete abduction and slight flexion,

FIG. 6A.—Baldwin's operation. Flat hand with adducted thumb due to paralysis of the small muscles of the hand. Note the helpless position of the thumb.

e.g., the normal position of grasp for the thumb and forefinger. The articular cartilages are cut from the trapezium and the base of the first metacarpus. "The wound is closed and the thumb fixed in the functioning position for three weeks. Fullest abduction and internal rotation of the thumb are absolutely essential." The pincer action of the thumb is now made possible and this action is valuable in performing the delicate movements, but unfortunately the grip of the thumb is not restored. (Figs. 6—A, B, C.)

In Steindler's operation for the plastic substitution of the oppens action of the thumb the sheath of the flexor longus pollicis is split and the tendon divided longitudinally, one-half of the tendon is inserted into the outer side of the base of the first phalanx and sutured to the periosteum. The sheath of the flexor longus pollicis is then closed. This half of the tendon is now running in the direction of the paralysed oppens pollicis, and each flexor movement of the

thumb will be accompanied by an opposition movement of the thumb against the fingers.

Ney's operation is a tendon transplant for paralysis of the intrinsic muscles of the hand. The greatest disability of this condition is the loss of the opposing action of the thumb. To overcome it " The short extensor tendon of the thumb is passed through a tunnel under the anterior annular ligament and transplanted into the tendon of the palmaris longus," or that muscle being

FIG. 6B.—Baldwin's operation of arthrodesis of basal joint has been performed and the thumb placed in the position of grasp.

absent (about 20 per cent. of cases), into the flexor carpi radialis without the division of this latter's tendon.

The Treatment of Stiff Metacarpal Joints.—Under this head we will take up the cases in which there is no gross bony change, but where the flexion of the metacarpal joints have been interfered with by changes in the joint capsule, contracture of the extensor tendons, involvement of these tendons in the scar, or a combination of all three. This latter condition is quite common after infection. Stiffness of the metacarpo-phalangeal joints is always a serious disability because without flexion at the metacarpo-phalangeal joints a good grasp is impossible. The disability is said to be caused by improper splinting. In our experience this is by no means the whole story, we have seen it occur as a sequel in cases of nerve injury and in cases of cellulitis where massage and suitable movements were instituted from the very earliest moment.

From an academic standpoint it is interesting to differentiate between tendon shortening and fibrosis of the joint capsule. From the standpoint of treatment it is immaterial to know which is the predominating element.

Dickson has suggested the following simple test. Pressure is applied to the head of the first phalanx until the metacarpal joint is flexed as far as possible, if active flexion of the interphalangeal joint is possible the limitation is due to a stiff carpo-phalangeal joint. If the interphalangeal joint cannot be passively flexed except when extension of the metacarpal joint takes place, then the condition is one of tendon shortening or tendon involvement.

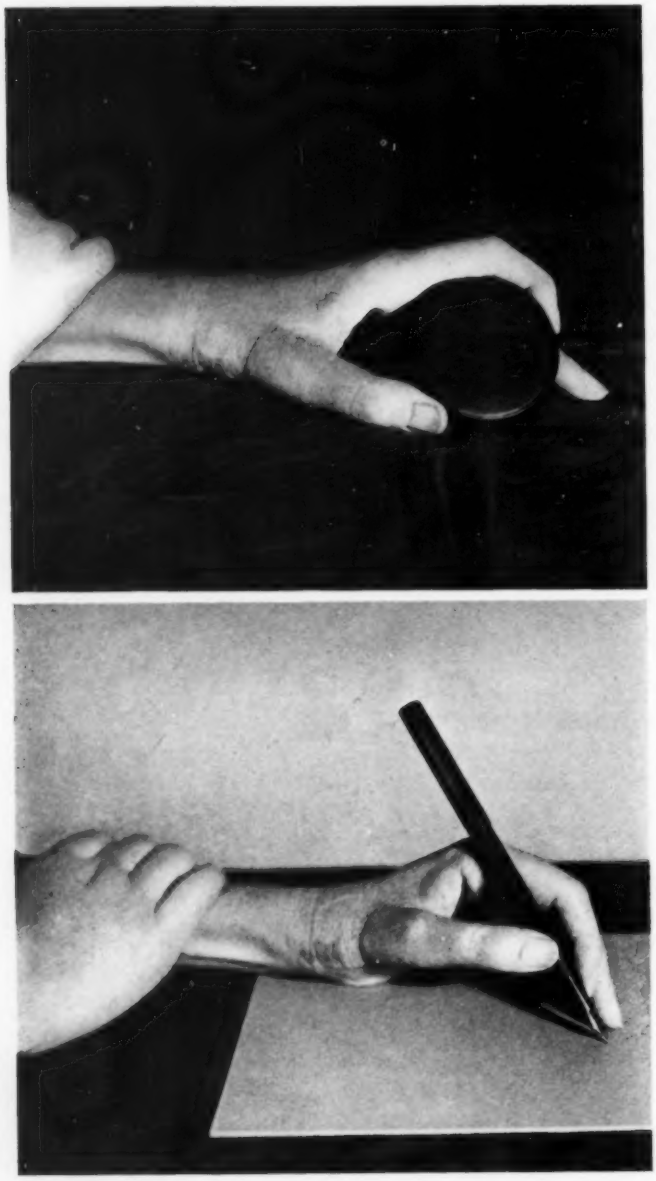

FIG. 6C.—Functional result eight weeks after operation.

The treatment of stiff metacarpal joints requires pains, patience, perseverance and time.

The four following methods are used in the treatment of this persistent disability. Manipulation under anæsthetic with fixation of the fingers in flexion; division of the thickened capsule with fixation of the finger in flexion; traction with gradual flexion; gradual correction by means of plaster.

The permanent results from mobilization under anæsthesia are very disappointing. Since the war (1915) we have not employed this method, except in a few mild cases where the disability was caused by light adhesions. We have no personal experience with the second, and this method does not appeal to us. In the mild cases we have used the traction

and distraction method with success, but in stubborn cases we have obtained our best results by Dickson's method of gradual correction.

In the traction method gradual flexion is carried out while traction is applied to the fingers. The traction is maintained in the line of deformity, until separation of the joint surface is obtained. The direction of the traction is then altered and progressively changed as indicated. During the day traction should be omitted for a few short intervals to permit of massage and exercises. The wrist is fixed in a bi-valve plaster splint in 30° dorsi-flexion. A loop of strong, malleable iron wire surrounds the finger tips and furnishes the bar to which the traction from the fingers is attached. For this purpose Baldwin has constructed an ingenious adjustable finger traction splint.

Treatment by Dickson's method of gradual flexion with plaster. "The metacarpal joints are gradually flexed with plaster; then by means of a retaining splint, this flexion is maintained between massage treatments until there is full voluntary flexion and no tendency to relapse. The ability to flex the joints voluntarily and retain the flexion is the indication for the removal of the splint." The first step consists in the application of a plaster case and the cutting of a window to expose the fingers. A general anæsthetic is preferable but not a necessity. Under anæsthesia, light adhesions are broken up and the maximum flexion of the metacarpals obtained. The hand, forearm, elbow and enough of the upper arm to fix the elbow are suitably padded with cotton, excessive padding is to be avoided otherwise the cast will work loose and slip. The hand is placed in the "cock-up" position and the metacarpals flexed as far as possible. The plaster is then applied to include the hand, forearm, elbow and lower third of the upper arm. The thumb is left free. When the cast becomes hard the portion of its palmar surface over the fingers is cut to allow the tips of the fingers to come out. This leaves a plaster cock-up extending half way up the palm. The second step consists in a gradual flexion of the metacarpo-phalangeal joints by wedging with felt pads. The felt pads are wedged between the dorsal beak of the splint and the heads of the first phalanges. The metacarpals being fixed in the cast, the wedging force flexes the metacarpo-phalangeal joints and stretches the contracted structures. This force acting on the heads of the phalanges at right angles to the shaft gives the maximum leverage without any tendency to impaction. The pads are

FIG. 7A.—Treatment of stiff metacarpal joints, contracture of extensor tendons, etc., by Dickson method. Condition of hand on admission. The fingers are fixed in the position shown.

fixed with plaster to prevent their removal, the patient is instructed to pull his fingers and thus increase the flexion. The pads become quite loose in a few days and additional wedges have to be applied. This procedure is repeated until the metacarpo-phalangeal joints are completely flexed, this takes about four weeks. When the maximum flexion is obtained it is to be retained for a week or ten days. The third step consists in the removal of the plaster beak and the employment of a flexion retaining bar. A notched piece of metal to act as a guide for the traction wire is inserted on the palmar surface of the wrist, and an anchoring metal ring near the elbow. A padded bar is placed over the head of the phalanges, and from the centre of this a wire runs over the guide post to a traction spring, this spring being in turn fixed to the anchoring ring at the elbow. By adjusting this spring sufficient force can be applied to keep the fingers flexed. It is important to see that the bar rides over the head of the phalanges. The bar is removed during massage, etc. This stage of the treatment occupies ten days to two weeks. The fourth step consists in the removal of the original cast and the application of a short cock-up splint, the flexion retaining apparatus being attached to a laced cuff above the elbow.

FIG. 7B.—Shows palmar aspect of cast cut away and the method of inserting the felt wedges between the beak of the cast and the first phalanges. Complete flexion at the metacarpo-phalangeal joints has been obtained.

The cuff and traction straps allow free motion at the elbow while the metacarpo-phalangeal joints are kept in full flexion. The apparatus is not to be removed until the patient has obtained the power to flex the joints and retains the flexion. Any tendency to relapse is an indication for further splintage. If it should be necessary to obtain flexion of the interphalangeal joints, traction tapes are attached to the fingers and the retaining bar discarded. These traction tapes should never be used until full flexion of the metacarpo-phalangeal joints are obtained, for if the proximal phalanx is in the extended position the major portion of the force applied will cause impaction. Figures 7—A, B, C, D, E, show the treatment and results obtained by Dickson method.

Treatment of Painful Scars.—If after a reasonable time, no improvement is obtained from physiotherapy, then a thorough excision of all the scar-tissue should be carried out. In addition, one inch of the cutaneous nerve supply should be excised, or the nerve injected with absolute alcohol and the wound closed immediately by suture or by a suitable full thickness pedicle graft.

The Treatment of Painful Finger Stumps.—This condition seldom occurs in aseptic cases, if the proper methods of amputation and after treatment are followed. Unfortunately, in the finger stumps resulting from laceration and infection, and despite all care, the patient may be left with an exquisitely tender stump, often the whole finger is involved. The skin, in the earlier cases has a bluish-red, glossy, ill-nourished appearance, in the later stages a certain toughness and lack of pliability. The fact that the amount of disability appears to be entirely out of proportion to the lesion, has led many men to unjustly accuse these sufferers of malingering; the large majority of these cases have a real pathological basis for their pain and tenderness. "He jests at scars that never felt a wound."

FIG. 7C.—Shows padded traction bar over heads of phalanges, the notched metal guide, the traction wire, spring and anchoring ring.

The studies carried on during the war have thrown much light on this disturbing condition. Foreign bodies or bacteria were found in almost all cases of fibroneuromata. The study of the cicatricial tissue showed that the nerves, as well as the surrounding structures, were infiltrated with a dense inflammatory tissue. The nerve filaments and the nerves, instead of following their recognized anatomical paths, were found to follow various structures. They accompanied the newly formed blood-vessels, worked their way into the tendon sheaths or wandered aimlessly about, crossing and recrossing, until they made a veritable network, and all this without apparent rhyme or reason.

Todd has called attention to these findings and concludes that the pain in many of the amputation stumps is due to the generalized inflammatory condition of all the tissues and not of the nerves or nerve endings only. Any operation for relief of pain or tenderness in such finger stumps will not be wholly successful, if a zone of latent infection is entered in the reamputation. With this we heartily agree.

Local operative interference is worse than useless, it stirs up trouble and

aggravates the condition. If you cannot amputate through healthy tissue it is better surgery to leave these fingers alone until the pain disappears.

Treatment of Mutilations of the Hand.—Partial amputations of the hand are of infinite variety, frequently atypical, and often complicated by contractures and impotent fingers.

We will confine ourselves to a few general principles and take up more in detail the mutilations of the thumb and their plastic repair. In partial amputations of the hand, the object is to try and utilize to the best possible advantage those structures which are intact, or are capable of being made to function

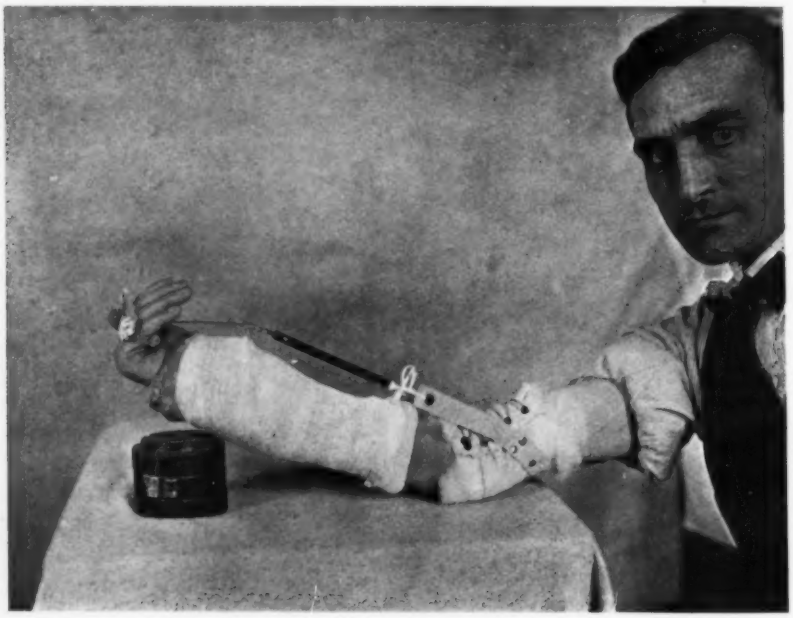

FIG. 7D.—Short splint, elbow free, flexion retaining apparatus attached to a laced cuff above the elbow.

and only to have recourse to a prothesis when it can aid the remaining functioning structures. Good looks and function often go together, but if necessary good looks must be sacrificed to good function, the only criterion of success in the hand being restoration of function.

As the strength of the palm depends on the integrity of the relationship of the metacarpals, it is essential to preserve the heads in all metacarpophalangeal amputations. The unnecessary sacrifice of such an important keystone is hardly justified by the excuse that soft parts are scanty, as a flap can be readily obtained from the chest or abdomen. To sacrifice it for the sake of improving the symmetry of the hand is a serious error. A primary comparison of the symmetry of such hands will be in favor of the hand in which the head has been excised. If the same comparison is made six to eight months later, it will be noticed that the atrophy of the bone and sur-

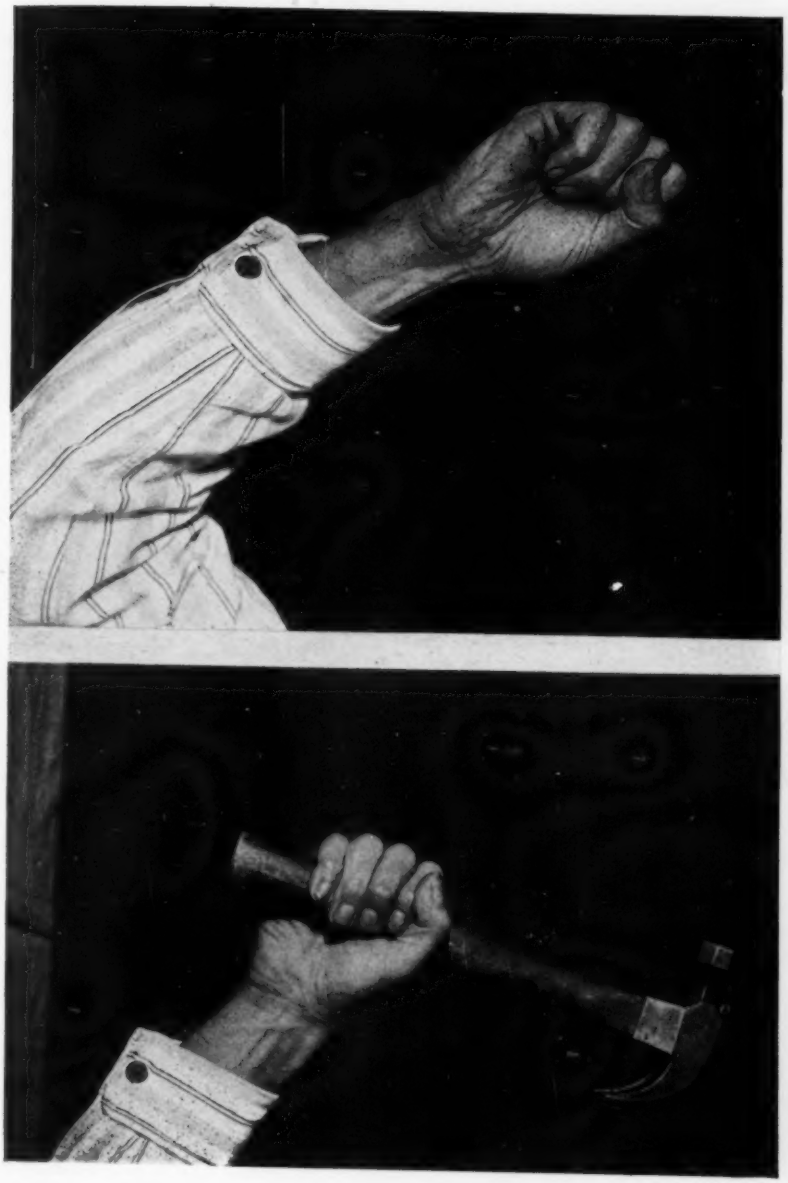

FIG. 7E.—Show the functional results obtained nine months later.

FIG. 8A.—Huguier's operation. Eight years after mutilation of hand by burns, with total destruction of little finger, partial of the index and total of the thumb, with the exception of a small stump of the first metacarpal.

FIG. 8B.—Plastic repair of the contractures by flaps from the abdomen.

rounding parts will have greatly diminished the gap between the fingers and that the symmetry of the hand compares favorably with the unduly narrow hand. The functional comparison is all in favor of the hand in which the head is retained. The excision of the head, besides resulting in a weak hand, often leads to a tender palm which renders the hand useless.

Mutilation of the thumb is a serious functional handicap, not only in itself but also in its effect on the remaining fingers, the destruction of the thumb destroys the most important arm of the prehensil forceps. From a functional standpoint the thumb is more valuable than four fingers. Its loss is rated by the French as a 25 to 35 per cent. disability. The English rate it as a 30 to 40 per cent. disability, considering it the same as the loss of four fingers. The loss of one or more fingers especially the last three, does not diminish to a great extent the functional value of the hand if it leaves the pincer action of the thumb intact.

FIG. 8C.—Huguier's operation. Functional result nine months later. Note grasp.

A great deal of attention has been focussed on the mutilations of the thumb, especially on the loss of the thumb and its metacarpus. The procedures employed to overcome these serious disabilities can be divided into two groups. To the first group belong the two plastic methods of Nicoladoni (1897–98). a. The formation of an opposition finger stump by an autoplastic pedunculated skin flap which contains a free bone graft. The bone graft gives the necessary rigidity and supplies the point of opposition for the pincer action. b. An autoplastic transplantation of a finger or toe to replace the thumb.

In contrast to this we have a second group of procedures which instead of employing the transplants from a distance utilize the structures at hand to

produce a new thumb. a. To this group belong Huguier's operation (1852) (phalangization or clefting) in which a new thumb is made from the first metacarpus. b. Finger substitution. c. Rotation of the remaining fingers.

In the complete loss of the thumb, Lauenstein (1880) did an osteotomy of the second and fifth metacarpals and rotated the index and little fingers so that their palmar surfaces faced each other. In this manner the hand was hollowed and a certain amount of grasp obtained. d. A combination of the above three methods, as performed by Perthes phalangization, finger transplantation and rotation.

FIG. 9A.—Result of Huguier's operation. Formation of a new thumb from stump of first metacarpus. Boy aged nine. Thumb, index, middle and ring fingers blown away by an exploding shell fuse July 20, 1916, Montmacq Oise, France. He sustained a serious compound comminuted fracture of remaining metacarpals, with extensive laceration of soft parts. Treated by Carrel method. Operation July 30, 1916.

Treatment of Mutilations of the Thumb Where the First Metacarpus or a Substantial Portion of it Remains Intact.—Such cases are to be treated by Huguier's operation (phalangization) or by Nicoladoni's second method. A short but useful thumb is obtained by Huguier's operation. This new thumb is made from the metacarpus, Huguier taking advantage of the well-known mobility of the first metacarpus, rendered its inferior half free by enlarging the first interosseous space.

Technic.—The incisions will vary with the scar-tissue and with the amount of available skin. With the hand prone make a dorsal incision midway between first and second metacarpals, the upper extremity corresponding to the middle of the high portion of the interosseous space. This dorsal incision exposes the external border and base of the first interosseous and the dorsal aspect of the metacarpals. Divide the interosseous where it is attached to the bone and reimplant. If present, expose the tendon of the adductor of the thumb, detach it from its insertion on the first phalanx and reimplant. Suture skin edges from before backward. (Figs. 8—A, B, C. 9—A, B. 10—A, B, C, D.)

This operation has been modified, in suitable cases, by the excision of the second metacarpus to deepen the cleft and improve the grasp. By this method Perthes produced a useful hand in a girl who had lost all five fingers. He mobilized the first metacarpus, excised the second and third and performed an osteotomy on the fourth and fifth. By excising the second and third metacarpals he obtained a deep cleft which increased the mobility of the first metacarpus. By sectioning the fourth and fifth metacarpals he was able to rotate them so that the palmar surface of this portion of the stump faced the new thumb, thus obtaining a better pincer action for the new hand.

FIG. 9B.—Huguier's operation. Functional result September 3, 1916. Note the writing and the grasp of the new thumb.

Nicoladoni of Graz, after having given up his first method, developed his toe transplantation operation in 1898. He made a new thumb by grafting the second toe to the stump of the first metacarpus. The functional result was only fair, the morphological poor. This principle has now been extended and applied to other fingers and toes. In Nicoladoni's original case, as in a number of others now appearing in the literature, the transplantation was done on the base of a movable metacarpus. The functional results are variable and often hampered or spoiled by the adherence of the flexor tendons. Where the mobility of the first metacarpus has been impaired by scar-tissue, etc., this operation yields nothing more than an immobile opposition member. Under these circumstances the functional results are scarcely better than those obtained by Nicoladoni's first method.

Morestin, at the International Surgical Congress, New York, 1914, spoke strongly against this method, considering it next to useless. Some of the results obtained since the war, two of which we have been able to examine, show that the method is of value.

In properly selected cases Huguier's operation yields a better functional result.

Treatment of Mutilations of the Thumb Where Only a Small Portion of the First Metacarpus Remains.—Perthes reports a case in which the thumb, with the exception of a small stump of metacarpus and the index finger, was destroyed. He divided the second metacarpus 1 cm. above its base and transplanted it into the stump of the first metacarpus. Before securing it in place he rotated the transplanted second metacarpus 90° so that the palmar surface faced the remaining fingers. The result was a strong useful hand. (Figs. 11-A, B.)

FIG. 10A.—Huguier's operation. Formation of new thumb from first metacarpus. X-ray of original injury June 6, 1913. Note the damage to the epiphyseal cartilage of the metacarpus.

Treatment for Total Loss of the Thumb.—Joyce (1917) substituted the ring finger of the opposite hand for the thumb and produced a useful functioning member. Joyce suggests "that by suitable modifications in the details of this operation any lost part of a thumb can be similarly replaced by substituting for it a part of the finger of the opposite hand."

For the total loss of the thumb, Perthes has developed a procedure which appears to give good functional results. It is a combination of the methods employed in adjacent transplantations. 1. A new cleft is formed between the index metacarpus and the third. 2. The index metacarpus is transplanted to the trapezium to take the place of the thumb. 3. The index finger, as in the Lauenstein method, is rotated so that its palmar surface is in the normal position of grasp and fixed in this position. (Fig. 12.) If this cannot be obtained by modelling the index metacarpus to the saddle-shaped surface of the trapezium, then an osteotomy with 90° rotation must be performed on the transplanted metacarpus. In carrying out this method care should be taken to avoid any unnecessary damage to the intrinsic muscle of the hand. If any tendons of the thumb can be salvaged from the stump these tendons should be secured to the metacarpus or fastened to the appropriate tendons of the new thumb. When the new thumb rotated into the position of grasp the flexor tendons act as abductors of the thumb, and the extensors as adductors.

FIG. 10B.—Condition of hand, showing the formation of a new thumb. July, 1913. Soft tissue has been grafted from abdomen.

FIG. 10C.—Huguier's operation. X-ray of hand nine years later. Note that the metacarpus has developed greatly.

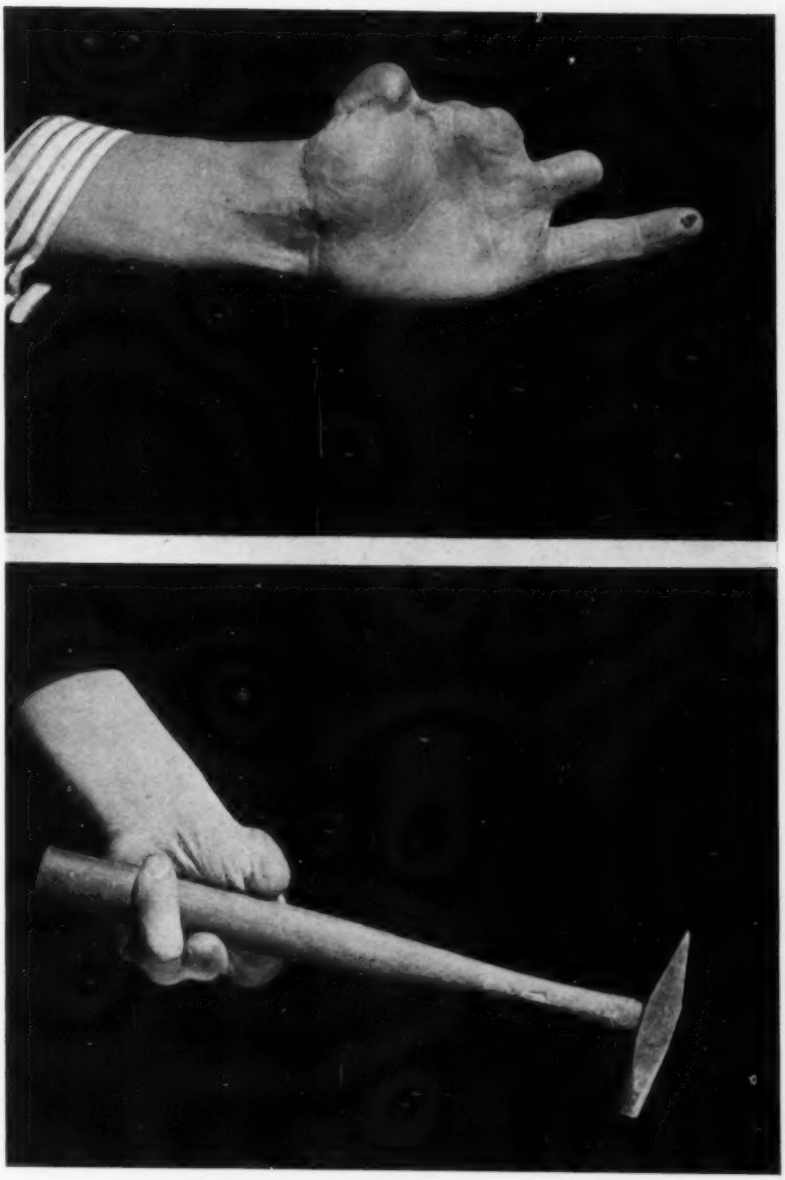

FIG. 10D.—Huguier's operation. Show result after nine years of functional use. This patient has been driving a taxicab in New York for two years.

Treatment of Mutilations of the Hand Where the Thumb Alone Remains.—The problem is to produce an opposition member. If any metacarpals are present this can be done either by clefting or by transplantation of a toe or a finger, or by a free bone transplant. In a case where the thumb was intact and the four other fingers and metacarpals missing, Albee synthetically grafted a stationary finger by the Italian method. The bone for the necessary rigidity was obtained by free graft from the tibia. This wedge-shaped bone

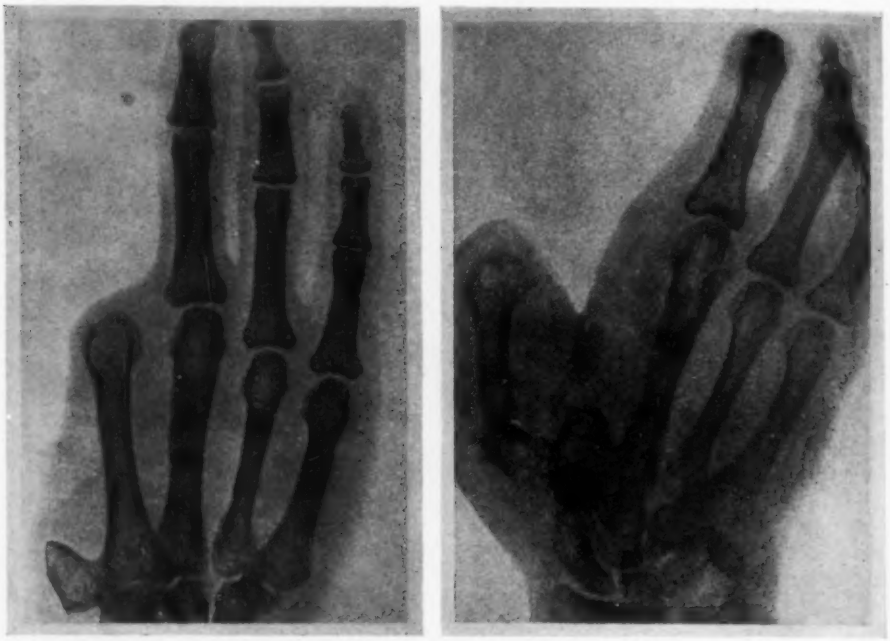

FIG. 11A, B.—Perthes' operation for mutilation of thumb, where only small portion of first metacarpal remains. Index metacarpal divided 1 cm. above its base and transplanted to stump of first metacarpus, it was rotated 90° and sutured in the position of grasp. A strong useful hand was obtained. (See Perthes.)

graft being driven into a mortise in the os magnum, made a stationary but strong opposing member.

Summary.—"The dense, cold, stiff fingers with smooth bluish-red skin that are left after the storm of infection has passed are poor material for any reconstructive surgery." The lesions we encounter, as a rule, involve several structures and their treatment often calls for different procedures at different stages. When to interfere surgically requires judgment, knowledge and experience.

The maximum nutritional and functional improvement should be obtained by conservative means before embarking on any difficult or extensive reconstructive surgery.

The treatment of many of these cases extends through a long period of time and we must keep in mind Hunter's famous teaching, that the power to heal is the property of living tissue, but the power to recover function—

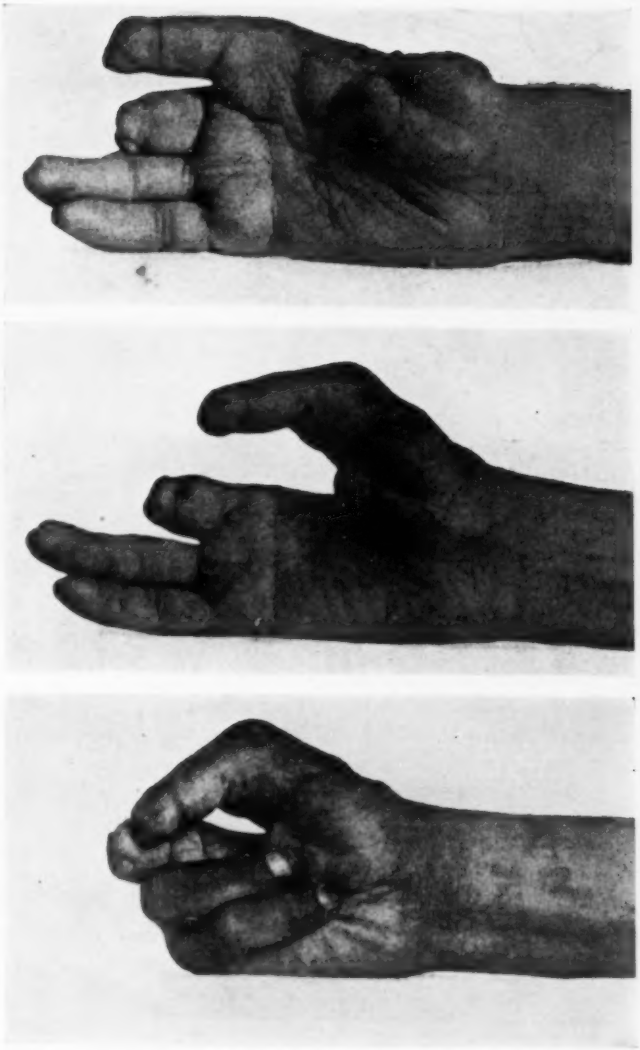

FIG. 12A, B, C.—Shows the result of Perthes' operation for total loss of thumb. A new cleft is formed between index metacarpus and the third metacarpus. The index metacarpus is transplanted to trapezium to take the place of the thumb. Note the rotation of the transplanted index. (See Perthes.)

the function of muscles and joints—is the property of the patient's will and brain. It is our duty to direct, encourage and interest the will and brain. Keith has aptly said: "We must not make the mistake of supposing that elaborate batteries, gymnastic machines, etc., can take the place of the thinking brain of the surgeon and the willing response of the disabled patient." In other words, good surgeons, like great artists, must mix their paint with brains.

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GIANT CELL SARCOMA OF THE FEMUR (EPULIS TYPE) WITH METASTASIS IN THE FEMORAL VEIN

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The so-called giant-celled sarcomata of the epulis type in bones form an anatomically and clinically well-defined group. Characterized histologically largely by spindle-shaped connective-tissue cells with a variable, but generally quite abundant, number of characteristic multinucleated giant cells, these growths are easily recognized microscopically. Grossly also, their frequent occurrence in the epiphyses of the long bones, the circumscribed, hemorrhagic and occasionally soft, jelly-like and cystic appearances and the local replacement of the bone, are conspicuous features.

The opinion has been growing that these growths are purely local affections and consequently clinically benign. It is shared to-day by a number of competent pathologists and surgeons. Thus Ewing states that he has never known these tumors to yield metastases; Martland writes, "They recur after complete removal, in loco, but I have never seen one metastasize to distant parts," and in fact, he doubts the tumor character; Meyerding omits them from his studies of "Sarcoma of the Long Bones" carried on at the Mayo Clinic because they are considered non-malignant. Similar conclusions are reached by Bloodgood and some others.

Without questioning this general experience and opinion regarding the nature and biological behavior of these growths, the following case is presented as an exception, and more particularly to illustrate the difficulty which confronts the pathologist and the surgeon in the decision as to the nature of neoplastic growths from purely histological evidence. In other words, is it possible to ever state with definite assurance that any growth of so labile and embryonic structure is benign and is the biological position of a tumor always accurately reflected by the histological picture? One must bear in mind that the classification of growths is fundamentally only of didactic value and that precise "pigeon-holing" of these conditions is not supported by natural laws, but remains more or less artificial and academic.

Frank W., a farmer, age forty-one, American, was a strong healthy individual until five months ago. At that time he was working in a quarry and struck his left knee on a piece of stone. This merely made him limp temporarily and he continued work for three weeks. At the end of that time the knee became painful and swollen, movement was limited, and he was forced to give up his employment. He consulted a physican who gave various local treatments and

finally a six weeks course of X-ray treatment. The knee became gradually more and more swollen and three weeks before admission (approximately seventeen weeks after the injury) the thigh became swollen to the groin and greatest difficulty was experienced in moving the limb both because of its great weight and because of weakness on the part of the patient.

Family History.—The patient has three brothers and one sister alive and well. His father died at the age of sixty-five and his mother died at the age of sixty-three. The cause of death in each case is unknown to him. There is no history of cancer or tumor.

Status Præsens.—Admitted to the Royal Victoria Hospital, orthopædic service of Dr. W. G. Turner, by ambulance May 31, 1922. Temperature, pulse

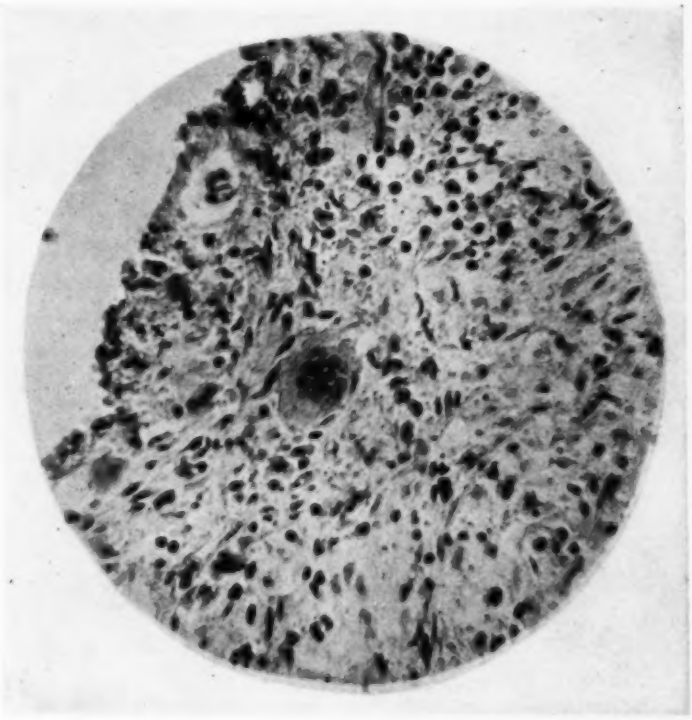

FIG. 1.—A microphotograph of the primary growth in the distal extremity of the femur.

and respirations normal. The patient is a large powerfully built man appearing stated age. Cheerful mood. Obese. Lies in bed with left leg in moderate flexion at the hip and knee and in slight external rotation. This leg is hard, œdematous, does not pit on pressure and measures 5½ inches more in circumference at the thigh and 3 inches more in circumference at the calf than the right leg. It is so swollen and the œdema is so hard that palpation is extremely difficult but there is definitely greater enlargement on the inner side of the lower third of the femur and on the outer side of the popliteal space. The heart and lungs, digestive system, genito-urinary system, and nervous system are negative.

Laboratory Examination.—Blood: Red blood cells, 5,000,000. White blood cells, 8,000. Hæmoglobin, 85 per cent. No abnormal blood picture, Wassermann negative. Urine: Sp. Gr., 1022; acid, clear, no albumen, no sugar, no casts. Dr.

A. H. Pirie, radiologist, submitted the following report: "The X-ray of the knee-joint shows the presence of a malignant tumor arising at the lower end of the femur. It has eroded the femur both in front and behind just above the epiphysis. The tumor has a capsule which casts a shadow suggestive of a little bone or calcification in its periphery. There is also a second large nodule with radiating lines in it going downwards and backwards from the lower end posterior to the main mass of the tumor. The appearance is more suggestive of sarcoma than any other lesion. An X-ray made of the lungs does not show any definite secondary growth."

Clinical Diagnosis.—Sarcoma of the left femur. Thrombosis of the left femoral vein.

Operation.—On June 8th, the left leg was disarticulated at the hip. Notes: Ether well taken. Incision over femoral vessels. Hard œdema and great depth to

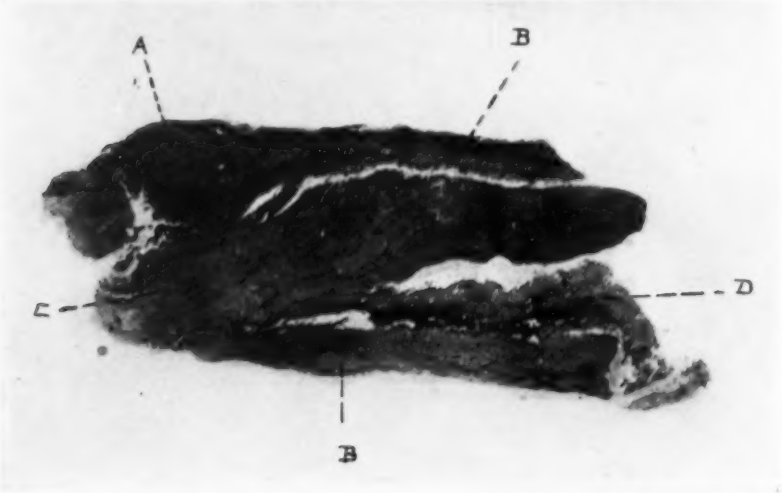

FIG. 2.—Longitudinal section of femoral vein in stump. The section is cut slightly obliquely. A. Tumor growth in vessel wall. B. Venous wall. C. Thrombus. D. Hemorrhagic organizing granulation tissue.

expose vessels. Femoral artery much diminished in volume. Vein completely thrombosed. Both ligated. Circular amputation of upper third and limb removed. Practically no hemorrhage. Disarticulation rapidly done and large flaps partially sutured. Dressing.

The following report (surgical 790/22) was submitted by the pathological department.

Macroscopical Examination.—1. A left leg which has been amputated about the junction of the upper and middle third; it is markedly swollen, œdematous and firm. Over the knee is a roughened area where the skin is thickened and desquamating. 2. Approximately the upper third of the femur including both trochanters, head and part of the shaft, with some tags of muscle and tendon adherent thereto.

After fixation and freezing the leg was split with a band saw and the section shows a tumor growth in the lower end of the femur. This growth is dark red in color, of a gelatinous homogeneous appearance and towards the centre shows cystic softening. It has completely destroyed the bony tissue and projects beyond the bony outline, but as far as can be seen in this gross specimen it is still surrounded by the periosteum and synovial membrane covering the end of the bone.

The capsule thus formed has been expanded by the increasing tumor mass so as to encroach on the joint cavity, but the cavity itself has not been invaded by the growth. In its longitudinal and transverse diameter it measures 9 by 7 cm.

Microscopical Examination.—Where the tumor is best preserved it is seen to consist of cells which are apparently of connective tissue derivation. For the most part they are elongated or spindle-shaped. Others are more embryonic and are oval or round. Fibril formation is not a marked feature, but rather a tendency to fuse. Many large typical giant cells with centrally placed nuclei are scattered throughout. Towards the periphery of the tumor spicules of bone in various stages of destruction complete the picture. Diagnosis: Giant-cell Sarcoma (Epulis Type).

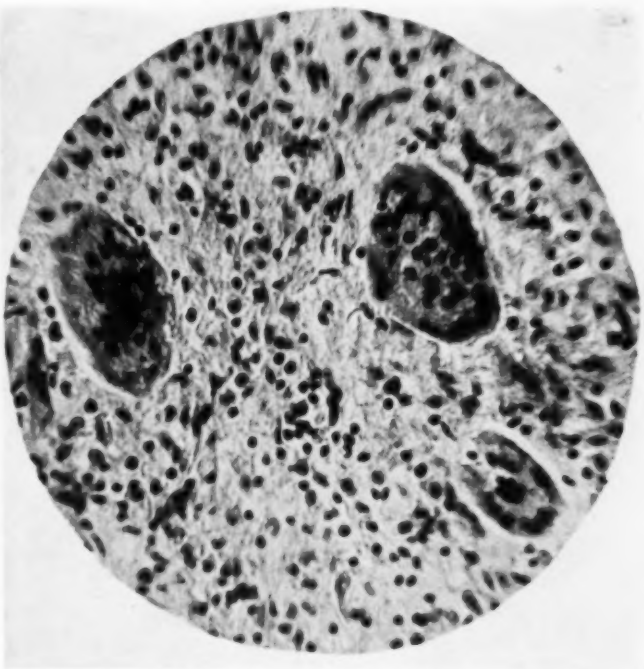

FIG. 3.—A microphotograph of the metastatic growth in the wall of the femoral vein at the groin.

Course.—General condition following operation excellent. Dressings every two days and condition improved steadily. Patient could move in bed easily and had only moderate pain referred to toes. Œdema of the stump however persisted. No pitting. July 8th (one month post-operative): Patient feeling quite well until 11:25 A.M. when, on raising up in bed, he suddenly complained of abdominal pain and rapidly lost consciousness. He died in a few minutes with cyanosis of the face and lips.

Summary protocol of autopsy findings. Section performed eight hours post-mortem by Doctor Grant. The body is that of a very fleshy male, and appears of stated age. Chest and abdomen are well developed. Has had a recent operation of disarticulation of the left leg at the hip-joint. The stump of the leg is much swollen; about five inches more in circumference than the right. At the end of the stump is an open wound 10 cm. long, infiltrated around by a bluish-red granulation tissue, ending in a closed scar 12 cm. long. The stump is closed by an anteriorposterior flap. Above the main incision scar are two longitudinal incisions into the œdematous tissue, each about 5 cm. long. The stump is firm and does not pit on pressure. Cyanosis is marked in the face and neck.

On opening the thorax the lungs lie free, collapsed superiorly, but retain their shape inferiorly where they are subcrepitant. The præcordial space is wide and there is a large amount of mediastinal fat. Pleuras free except for slight apical

scarring. Pericardium is free. Section of the lungs shows no evidence of neoplastic involvement.

The right side of the heart is considerably dilated; the left side is contracted and firm. The right auricle contains fluid blood and post-mortem clot. The tricuspid orifice admits three fingers. There is a recent, red, soft thrombus attached to the tricuspid valve. The right ventricle contains post-mortem clot. On opening the pulmonary artery there is found a large yellowish-gray, firm, but friable embolus extending upwards from the pulmonary valves to the bifurcation. The left side of the heart is free. Musculature yellowish but firm. The coronary arteries are free.

On opening the abdomen the parenchymatous organs are found relatively normal. There is general evidence of passive congestion; the spleen is hyper-

FIG. 4.—Longitudinal section of the left leg at the knee, showing the primary growth in the femur.

plastic and the kidneys tend to bulge. On opening the inferior vena cava there is found a large but only very slightly adherent thrombus which extends upward from the bifurcation for a distance of 5 cm. The right common iliac vein below this point is free. The left common iliac vein is free for a short distance (probably separation), but at its bifurcation and extending down the left external iliac there is an old yellowish, pinkish to grayish, firm and adherent, rather fibrinous thrombus. This condition extends down into the amputated femoral region. The aorta shows very slight fatty intimal changes.

Microscopic Examination.—Sections from the embolus in the pulmonary artery present the typical picture of coagulated fibrin, red blood cells, leucocytes, etc. All rather necrotic looking. There is no evidence of neoplastic cells in the embolus. Sections from the thrombus in the inferior vena cava present a similar structure, with no evidence of neoplastic involvement. Sections from the femoral vein in the stump, present, however, a different picture. Within the lumen of the vessel lies a thrombus which at the centre is made up purely of necrotic, poorly staining more or less homogeneous fused fibrin, leucocytes, etc., while peripherally it is in part invaded by granulation tissue with many proliferating fibroblasts,

endothelial buds and some small round cells. One portion of the wall of the vein however has been definitely replaced in this situation by a nodular neoplastic growth, which simulates the original growth in the lower end of the femur except that it is slightly more embryonic (sarcoid) in character. This growth is thus inserted into and coextensive with the vessel wall. It is composed microscopically of large immature connective tissue cells which show only slight tendency to fibril formation and rather remain in an embryonic spindle-cell stage. Scattered throughout are large giant cells containing many irregularly arranged nuclei (typical epulis giant cells). The growth is vascular and furthermore infiltrated by a large variety of small round cells, lymphocytes, polymorphonuclears, large round cells often with lobated nuclei and transitions into plasma cells and eosinophiles. This infiltration is for the most part diffuse, but in places appears more intense or focal in character. It simulates in some areas myeloid tissue, but special stains do not substantiate this impression.

Sections of the heart show parenchymatous and slight fatty degeneration. The lungs give evidence of a moderate, but rather long standing passive congestion at the base. This condition is also present in the abdominal viscera. There is hyperplasia and pigmentation of the spleen and the prostate is the seat of a glandular hyperplasia.

Anatomical Diagnosis.—Pulmonary embolus; giant cell sarcoma (epulis type) in wall of left femoral vein with secondary thrombosis of femoral and external iliac veins and inferior vena cava; recent amputation of the left leg at the hip for giant cell sarcoma of distal extremity of femur. Passive congestion of lungs and abdominal viscera; parenchymatous degeneration of heart, liver and kidneys; slight fatty degeneration of heart; hypostasis of the lungs; hyperplasia and pigmentation in spleen; glandular hyperplasia of the prostate; fatty infiltration of the liver; obesity.

In retrospect we find an apparently clear-cut course extending over a period of approximately six months. Starting with a very definite history of moderately severe trauma of the lower end of the left femur in a healthy man, aged forty-one years, we have evidence of almost immediate development of a quite rapidly growing neoplastic process at the site of injury. The growth quickly erodes the bone, leaving only the periosteum. Within seventeen weeks a metastasis has occurred in the wall of the femoral vein leading to thrombosis. Unfortunately the location is high up near Poupart's ligament, so that amputation does not reach it. In the course of six weeks from the first evidence of thrombosis this condition has spread progressively up the iliac vessels and into the inferior vena cava. Slight exertion dislodges a large portion of the thrombus and pulmonary embolization brings about immediate death.

Two questions naturally arise for discussion. First, is the primary tumor a true giant-cell sarcoma of the epulis type? Secondly, is the growth in the femoral vein a metastasis? In answer to the first question, one may say that the tumor certainly presents both macroscopically and microscopically the characteristics of this type of growth and what variations from the usual picture occur may be attributed merely to its more active character, rather than to any real alteration in fundamental nature. Grossly it presents the usual reddish jelly-like replacement of the cancellous portion of the bone, with more rapid than usual absorption of the shaft, so the periosteum alone

remains. Histologically it is likewise typical, as shown by the accompanying microphotograph, and in no way to be confused with a malignant periosteal sarcoma containing fused tumor cells. The clusters of more embryonic, highly undifferentiated cells are but foci of active rapidly proliferating nature. The giant cells are typically abundant, large, diffusely scattered, with relatively clear pink-staining cytoplasm and contain many round or oval, discrete nuclei clumped for the most part centrally.

The growth in the vein, besides carrying an even macroscopically visible, nodular tumor character, and being thus easily distinguished and separated from the thrombus in the lumen of the vessel, presents a strikingly similar histological picture except that it shows even less tendency to fibril formation and a considerable infiltration of small round cells. The distance of this area from the original growth is approximately thirty centimetres and it seems quite improbable that its presence in the groin could be explained by direct extension; moreover the vein below the point of amputation is free from thrombosis and there is no evidence of growth in the tissue in this vicinity. That an embolic fragment from the original tumor entered the blood stream, lodged and took root at this point subsequent to the formation of the thrombus seems likewise untenable from the position of the tumor nodule well within the vessel wall. We must, therefore, come to the conclusion that we are dealing with a genuine metastasis in the wall of the femoral vein, and this is based on the position and tumor-like replacing character of the growth with its quite characteristic histological picture.

CONCLUSIONS

A case is presented of primary giant-cell sarcoma of the epulis type in the distal extremity of the femur with metastasis in the wall of the femoral vein. It shows that this tumor, generally held as local and benign, may metastasize and thus become malignant.

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INDEX TO VOLUME LXXVIII

A

Abdomen, The Influence of Hemorrhage on the Mortality in Gunshot Wounds and Other Injuries of the, 364.

Abdomino-thoracic Approach, Combined, in Operations for Diaphragmatic Hernia, 32.

Abscess of the Tongue, 496.

Acetabulum, Fracture of the, with Central Luxation of the Hip, 806.

Actinomycosis, 294.

Adams, Donald S.: Embryoma of the Kidney, 226.

Adventitia, Excision of, of Brachial Artery (Leriche Operation) for Raynaud's Disease, 428.

Alcohol and Work, Relation of to Cirrhosis of Mesentery and Sub-peritoneal Lipomatosis, 751.

Alexander, E. G.: Splenomegaly, 669.

American Surgical Association: Treatment of Fractures, 126.

Amputation Stump, Healed Trophic Ulcer of, following Peri-arterial Decortication, 428.

Anæmia, Splenectomy for Advanced Splenic, 408.

Anaphylaxis, Fatal, following Blood Transfusion, 1.

Aneurism of the Renal Artery, 628; Traumatic, of Femoral Artery, Bullet Wound of Thigh Producing, 403.

Ankylosis of Jaw, 539.

Anthrax and its Treatment, 326.

Arterial Transplants, End Results of, 305.

Artery, Brachial, Excision of Adventitia of (Leriche Operation), for Raynaud's Disease, 428; Femoral, Bullet Wound of Thigh Producing Traumatic Aneurism of, 403; Femoral, and Vein, Wound of, 84.

Arthritis of the Knee, Chronic Hypertrophic Villous, 104.

Arthrotomy, Fracture of Patella after, 106.

Ascarides Lumbricoides, Acute Intestinal Obstruction Due to Impacted, 401.

Ashhurst, Astley P. C.: Rupture of Tendon of Extensor Longus Pollicis, 87; Broncho-subphrenic-cutaneous Fistula, 99; Immediate Plastic Operations in Injuries Involving Tendons or Joints, 100; Rupture of Tendon of Extensor Longus Pollicis following a Colles Fracture, 398; Bullet Wound of the Thigh Producing Traumatic Aneurism of Femoral Artery, 404; Repair of the Musculo-spiral Nerve, 406; Technic of Inguinal Hernioplasty, 412.

Asthenia, Pancreatic, 177.

Axillary Artery, Embolus of, 549.

B

Balfour, Donald C.: The Use of the Cautery in Peptic Ulcer, 206.

Bancroft, Frederic W.: Chronic Cholecystitis without Stone, 608.

Bauman, George I.: Osteomyelitis of the Spine, 119.

Beer, Edwin: Periosteal Sarcoma of the Femur, 418.

Bile Duct, Common, Drainage of the, 620; Repair of the Common, 129.

Bladder, Bullet in the, 667; Carcinoma of the, 254; Diverticulum of the, 677.

Blood Transfusion, Fatal Anaphylaxis following, 1.

Bolling, Richard W.: Acute Intussusception in Infants, 349; Partial Colectomy for Megacolon, 680; Acute Intussusception in Infants, 681.

Bones, Long, Metal Plates in Fractures of the, 75.

Boothby, Walter M.: Importance in Surgery of the Thyroid Gland of Correct Differential Diagnosis of Thyroid Diseases, 572.

Bower, John O.: Management of Injuries to the Cranium and its Contents, 433.

Brachial Artery for Raynaud's Disease, Excision of Adventitia of, 428.

Bransfield, J. W.: Bullet Wound of Pregnant Uterus, 93; Immediate Plastic Operations in Injuries Involving Tendons or Joints, 100; Treatment of Webbed Fingers, 532, 543.

Broncho-subphrenic-cutaneous Fistula, 99.

Brooks, Barney: Administration of Sodium Chloride in Intestinal Obstruction, 755.

Browning, William: Review of Tilney on the Form and Functions of the Central Nervous System, 124.

Bruce, Herbert A.: Actinomycosis, 294.

Bullet in the Bladder, 667.

Bullet-wound of Pregnant Uterus, 93; of Thigh Producing Traumatic Aneurism of Femoral Artery, 403.

Burdick, Carl G.: Fractures of the Femur in Children, 421.

C

Calcareous Changes of the Gall-bladder Wall, 623.

Calculus, Renal, Certain Features of, 231; Vesical, 666, 668; Urachal, 668.

Carbuncles, A Conservative Treatment of, 649.

Cancer of the Colon, 210; of the Tongue, 461, 469, 474.

Carcinoma of the Bladder, 254.

Carcinoma of the Prostate, Transpubic Removal of, 795; of the Stomach, The Operative Curability of, 332.

Cardioplasty for Cardiospasm, 165.

Cardiorrhaphy in Acute Injuries, 696.

Cardiospasm, Cardioplasty for, 165; Operation for the Relief of, 174.

Carrington, George Lunsford: Fatal Anaphylaxis following Blood Transfusion, 1.

Caulk, John R.: Surgery of the Ectopic Kidney, 65.

Cautery in Peptic Ulcer, The Use of the, 206.

Central Nervous System, The Form and Functions of, Review of Tilney on, 124.

Cerebrum, Pneumoventricle of the, 561.

Cervical Nerves, Incised Wound of the Fourth and Fifth, 402.

Cheek, Plastic Repair of, 87.

Cheever, David: The Operative Curability of Carcinoma of the Stomach, 332.

Cholecystitis, without Stone, Chronic, 608.

Cholesterolemia, Hyper, Bile Drainage for, 594.

Cirrhosis of Mesentery, Relation of to Alcohol and Work, 751.

Clopton, Malvern B.: Eventration of the Diaphragm, 155.

Cohen, Harry: Scleroderma with Gangrene of Fingers, 814.

Colectomy for Chronic Intestinal Obstruction, 425; Partial for Megacolon, 680.

Coley, William B.: Sarcoma of Testis, 108; End Results in Malignant Disease of the Testis, 370; Inoperable Melanotic Sarcoma of the Neck, Entire Disappearance under Accidental Streptococcic Infection, 414; Periosteal Sarcoma of Fibula, 415; Periosteal Sarcoma of Femur, 417; Multiple, Herniæ, Inguinal, Femoral, Epigastric, 421.

Colles' Fracture, Rupture of Tendon of Extensor Longus Pollicis following a, 398.

Colon, Cancer of the, 210.

Colp, Ralph: External Duodenal Fistulæ, 725.

Conjoined Tendon, Hernia through the, 300.

Conroy, Michael J.: Aneurism of the Renal Artery, 628.

Copher, Glover H.: Administration of Sodium Chloride in Intestinal Obstruction, 755.

Cranial Injuries, Plan for the Management of, 674.

Cranium and Contents, Management of Injuries to, 433.

Crile, George W.: Special Points in Gallbladder Surgery, 192.

Cumston, Charles G.: Note on the Pathology and Surgical Treatment of Leukokeratosis Linguæ, 469.

D

Deaver, John B.: Enlargement of the Prostate, 126; Carcinoma of the Bladder, 254.

Deferentitis, Acute, 785.

DeForest, Henry Pelouze: Leucoplakia Buccalis, 474.

Despard, D. L.: Bullet Wound of Thigh Producing Traumatic Aneurism of Femoral Artery, 403; Repair of the Musculo-spiral Nerve, 406; Splenectomy for Advanced Splenic Anæmia, 408; Removal of Foreign Body from the Lung, 673.

Diet after Gastro-enterostomy, 118.

Diaphragm, Eventration of the, 155.

Diaphragmatic Hernia, 660; Combined Abdomino-thoracic Approach in Operations for, 32.

Digitalization, Pre-operative, Effect of in Reducing Post-operative Complications, 693.

Dislocation of Semilunar, 545; Subastragaloid, 536; of Tarsal Scaphoid, 544.

Dislocation Fracture of the Vertebræ, 260.

Diverticulum of the Bladder, 677.

Dorrance, George M.: Plastic Repair of Cheek, 87; Immediate Plastic Operations in Injuries Involving Tendons or Joints, 100; Treatment of Webbed Fingers, 532, 543; Result of Arthroplasty for Ankylosis of Jaw, 540.

Douglas, John: Treatment of Gastric and Duodenal Ulcer, 548; Acute Perforation of the Stomach, 679.

Downes, William A.: Splenectomy for Banti's Disease, 557.

Drainage, The Question of, in Intra-abdominal Infection, 121.

Dunham, Theodore: Periosteal Sarcoma of Femur, 418; Shock from Reduction of Intussusception, 683.

Duodenal Fistulæ, External, 725.

Duodenal Ulcer, Acute Obstructive, 427; Acute Perforation of, 342; Resection of Stomach for, 507.

E

Ear, Nose and Throat, Treatise on the Diseases of, by Wendell C. Phillips, Review of, 686.

Ectopic Kidney, Surgery of the, 65.

Eliason, E. L.: Septic Embolic of Mesenteric Arterioles, 672.

Eliot, Ellsworth, Jr.: Certain Features of Renal Calculus, 231.

Embolus of Axillary Artery, 549.

Embryoma of the Kidney, 226.

Empyema of the Pleural Cavity, 711; of the Ureteral Stump Following Incomplete Ureterectomy, 387.

Epigastric, Femoral, Inguinal, Multiple Hernia, 421.

Epilepsy, Pleural, 6.

Epiphysis, Lower Radial, Unreduced Separation of, 550.

Eventration of the Diaphragm, 155.

Extensor Longus Pollicis, Rupture of Tendon of, 398.

F

Farr, Charles E.: Intussusception, 681.

Femur, Fracture of, 108; Giant-cell Sarcoma of the, with Metastasis in the Femoral Vein, 846; Gunshot Fracture of the, and Wounds of the Femoral Vessels Requiring Amputation, 405; in Children, Fractures of the, 421; Periosteal Sarcoma of, 417; Ununited Fracture of, 550.

Femoral Artery and Vein, Wound of, 84; Artery, Bullet Wound of Thigh Producing Traumatic Aneurism of, 403.

Femoral Vessels, Myxosarcoma of Thigh Involving the, 422.

Fibula, Periosteal Sarcoma of, 415.

Fingers, Gangrene of, with Scleroderma, 814; Webbed, Treatment of, 532, 543.

Fischer, Hermann: Relation of Surgery to the Vascular Sympathetic System, 430; Diverticulum of the Bladder, 677.

Fisher, David: Wound of Femoral Artery and Vein, 84.

Fisher, William H.: Post-operative Infective Parotiditis, 568.

Fistula, Broncho-subphrenic-cutaneous, 99; Gastrocolic, 687; Transpleural Œsophago-cutaneous, 96.

Fistulæ External, Duodenal, 725.

Foreign Body in the Lung, Removal of, 673.

Foss, Harold L.: The Control of Hemorrhage following Prostatectomy, 802.

Fowler, W. Frank: Calcareous Changes of the Gall-bladder Wall, 623.

Fracture of the Acetabulum, with Central Luxation of the Hip, 806; of Carpal Scaphoid, 545; of Femur, 108; of the Femur in Children, 421.

Fracture, Gunshot, of the Femur and Wounds of the Femoral Vessels Requiring Amputation, 405; of Patella after Arthrotomy, 106; of the Surgical Neck of Humerus, 552.

Fractures of the Long Bones, Metal Plates in, 75; Treatment of, 126.

Fracture-dislocation of the Vertebræ, 260.

Freeman, Leonard: Operation for the Relief of Cardiospasm, 174.

Funiculitis, Acute, 785.

G

Gage, Homer: Embryoma of the Kidney, 226.

Gall-bladder Disease, The Meltzer-Lyons Test in the Diagnosis of, 604; Surgery, Special Points in, 192; Wall, Calcareous Changes of the, 623.

Gant's Treatise on Diseases of the Rectum, Anus and Colon, Review of, 685.

Gastric Ulcer, Perforation in Utero of a, 36.

Gastric and Duodenal Ulcer, Resection of Stomach for, 507, 546.

Gastrocolic Fistula, 687.

Gastro-enterostomy, Diet after, 118.

Geist, Samuel H.: Effect of Pre-operative Digitalization in Reducing Post-operative Complications, 693.

Gibbon, John H.: The Technic of Renal and Ureteral Surgery, 641.

Gibson, Charles L.: Treatment of Hand Infections by Active Mobilization, 423; Treatment of Hour-glass Stomach by Double Gastro-enterostomy, 587; Acute Perforation of the Stomach, 678; with Transposition of Viscera, 679.

Gibson, Thomas E.: Malignant Tumors of the Testicle in Children, 761.

Gill, A. Bruce: Result of Arthroplasty for Ankylosis of Jaw, 540; Treatment of Webbed Fingers, 532, 543.

Glucose Solution, Hypertonic, in the Treatment of Peritonitis, The Use of Intra-abdominal Injections of, 357.

Goitre, The Many-stage Operation for, 151.

Goldberger, Morris A.: Effect of Pre-operative Digitalization in Reducing Post-operative Complications, 693.

Gonzalez, A.: Pleural Epilepsy, 6.

Grover, Courtney P.: Wound of Femoral Artery and Vein, 84.

Gunshot Fracture of the Femur and Wounds of the Femoral Vessels Requiring Amputation, 405.

Gunshot Wounds and Other Injuries of the Abdomen, The Influence of Hemorrhage on the Mortality of, 364.

Guthrie, C. C.: End Results of Arterial Transplants, 305.

H

Hæmangioma of the Intestine, 42.

HAND, ALFRED: Transpleural Œsophagocutaneous Fistula, 96.

Hand, Disabilities of the, and Their Physiological Treatment, 816; Infections by Active Mobilization, Treatment of, 423.

HARKAVY, J.: Abscess of the Tongue, 496.

HARTWELL, JOHN A.: Periosteal Sarcoma of the Femur, 419; Relation of Surgery to the Vascular Sympathetic System, 430; Splenectomy, 557.

Head, Traumatic Lesions of the, 26.

Heart Suture in Acute Injuries, 696.

HELLER, EDWARD P.: The Question of Drainage in Intra-abdominal Infection, 121.

HELVESTINE, FRANK, JR.: Hæmangioma of the Intestine, 42.

Hemorrhage following Prostatectomy, the Control of, 802.

Hemorrhage, The Influence of, on the Mortality in Gunshot Wounds and Other Injuries of the Abdomen, 364.

HERMAN, LEON: Bullet in the Bladder, 667; Vesical Calculus, 668; Urachal Calculus, 668.

Hernia, Diaphragmatic, 660; Diaphragmatic, Combined Abdomino-thoracic Approach in Operations for, 32; Inguinal, Recurrence of, after Operation, 524, 558; Multiple, Inguinal, Femoral, Epigastric, 421; through the Conjoined Tendon, 300.

Hernioplasty, Inguinal, Technic of, 410; a Modified Inguinal, 48.

HEUER, GEORGE J.: Empyema of the Pleural Cavity, 711.

HEWSON, ADDINELL: Lane Plate Healed in Place, 534.

HEYD, CHARLES G.: Removal of Appendix in Cases of Intussusception, 683.

Hip, Central Luxation of the, with Fracture of the Acetabulum, 806.

HITZROT, JAMES M.: Use of Metal Plates in the Treatment of Fractures of the Long Bones, 110; Splenectomy in Hemorrhagic Purpura, 186.

HOGUET, J. P.: Technic of Operation for Inguinal Hernia, 559.

Hour-glass Stomach, Treatment by Double Gastro-enterostomy, 587.

Humerus, Fracture of the Surgical Neck of, 552.

HYMAN, ABRAHAM: Empyema of the Ureteral Stump following Incomplete Ureterectomy, 387.

Hypercholesterolemia, Bile Drainage for, 594.

I

Infants, Acute Intussusception in, 349.

Infections of the Hand Treated by Active Mobilization, 423.

Inguinal Hernia, Recurrence of After Operation, 524, 558.

Inguinal Hernioplasty, A Modified, 48; Technic of, 410.

Intestine, Hæmangioma of the, 42; Small, Extensive Resection of the, 745.

Intestinal Obstruction, 755; Acute, Caused by Chronic Organizing Peritonitis of Undetermined Etiology, 116; Acute, Caused by Meckel's Diverticulum, 92; Acute, Due to Impacted Ascarides Lumbricoides, 401; Colectomy for Chronic, 425.

Intra-abdominal Infection, The Question of Drainage in, 121.

Intracervical Enucleation, 61.

Intussusception, Acute, in Infants, 349, 681.

IVY, ROBERT H.: Ankylosis of Jaw, Arthroplasty for, 539; Repair of Loss of Bridge of Nose, 538.

J

JACKSON, CHEVALIER: Intercostal Thoracopuncture for the Removal of Penetrating Projectiles in the Lung, 501, 537.

Joints and Tendons, Immediate Plastic Operations in Injuries Involving, 100.

Jones and Lovett, Orthopædic Surgery, Review of, 128.

Jopson, John H.: Technic of Inguinal Hernioplasty, 410; Treatment of Webbed Fingers, 532, 543; Result of Arthroplasty for Ankylosis of Jaw, 542.

Judd, E. Starr: Mortality after Liver and Pancreas Operations, 195.

K

Kelly, James A.: Acute Intestinal Obstruction Due to Impacted Ascarides Lumbricoides, 401; Incised Wound of the Fourth and Fifth Cervical Nerve, 402; Bullet Wound of the Thigh Producing Traumatic Aneurism of Femoral Artery, 403.

Kleinberg, Samuel: Fracture of the Acetabulum with Central Luxation of the Hip, 806.

Klotz, Oskar: End Results of Arterial Transplants, 305.

Knee, Chronic Hypertrophic Villous Arthritis of the, 104.

Kidney, Ectopic, Surgery of the, 65; Embryoma of the, 226; The Surgery of the, 250.

Kidney-stones, Ossification in, 239.

Kutzmann, Adolph A.: Malignant Tumors of the Testicle in Children, 761.

L

Lahey, Frank H.: Intracervical Enucleation, 61.

Lane Plate Healed in Place, 534.

Lee, Walter Estell: Fatal Anaphylaxis following Blood Transfusion, 1; Perforation in Utero of a Gastric Ulcer, 36; Transpleural Œsophago-cutaneous Fistula, 96.

Lesions, Traumatic, of the Head, 26.

Leucoplakia Buccalis, 474.

Leukokeratosis Linguæ, Pathology and Surgical Treatment of, 469.

Le Wald, Leon: Megacolon, 680.

Lewisohn, Richard: Duodenal Ulcer, 546; Resection of Stomach for Chronic Gastric and Duodenal Ulcer, 507; Penetrating Ulcer of the Lesser Curvature of the Stomach, 545.

Lewis, Raymond W.: A Conservative Treatment of, 649.

Lilienthal, Howard: Sarcoma of Testis, 110; Use of Metal Plates in the Treatment of Fractures of the Long Bones, 110.

Linguæ, Pathology and Surgical Treatment of Leukokeratosis of, 469.

Lipomatosis, Subperitoneal, Relation of to Alcohol and Work, 751.

Liver and Pancreas Operations, Mortality after, 195.

Lower, William E.: The Surgery of the Kidney, 250.

Lucké, Baldwin: Multiple Myeloma of the Plasma-cell Type, 14.

Lumbricoides, Ascarides, Acute Intestinal Obstruction Due to Impacted, 401.

Lung, Foreign Body in the, Removal of, 673; Penetrating Projectiles in the, Removal by Intercostal Thoracopuncture, 501, 537.

Lyle, Henry H. M.: Ununited Fracture of Femur, 552; Technic of Operation for Inguinal Hernia, 559; The Disabilities of the Hand and Their Physiological Treatment, 816.

Lympho-sarcoma of the Tonsils with Cervical Metastases, 112.

Lyons, John H.: Mortality after Liver and Pancreas Operations, 195.

M

Mackinney, William H.: Carcinoma of the Bladder, 254.

Malignant Disease of the Testis, End Results in, 370.

Malignant Tumors of the Testicle in Children, 761.

Mandibular Joint, Ankylosis of, 539.

MARTIN, WALTON: Treatment of Hand Infections by Active Mobilization, 425.

MASON, JAMES MONROE: The Influence of Hemorrhage on the Mortality in Gunshot Wounds and Other Injuries of the Abdomen, 364.

MATHEWS, FRANK S.: Hernia through the Conjoined Tendon, 300; Fractures of the Femur in Children, 422.

MAYO, CHARLES H.: Surgery of the Thyroid and its Mortality, 146.

MAYO, WILLIAM J.: A Question of Size, 140.

MCARTHUR, LEWIS L.: Repair of the Common Bile-duct, 129.

MCCREERY, JOHN A.: Dislocation of Scaphoid of Tarsus, 544.

MCKAY, W. J. STEWART: His Life and Work, 122.

MCKENNA, DONALD E.: Orthopædic Surgery Reviewed by, 128.

MCWILLIAMS, CLARENCE A.: Fracture of Femur, 108; Treatment of Hand Infections by Active Mobilization, 424.

Meckel's Diverticulum, Acute Intestinal Obstruction Caused by, 92.

Megacolon, Partial Colectomy for, 680.

Meltzer-Lyons Test in the Diagnosis of Gall-bladder Disease, 604.

Mesenteric Arterioles, Septic Emboli of, 672.

Mesentery, Cirrhosis of, Relation of to Alcohol and Work, 751.

Metal Plates in Fractures of the Long Bones, 75.

Metastases, Cervical, Lympho-sarcoma of the Tonsils with, 112.

MILLER, C. JEFF: Gastrocolic Fistula, 687.

MILLER, ROBERT T., JR.: Cancer of the Colon, 210.

MITCHELL, CHARLES F.: Bullet in the Bladder, 668.

MORRIS, ROBERT T.: Etiology of Intussusception, 681.

MORROW, ALBERT S.: Recurrence of Inguinal Hernia after Operation, 524, 558.

Mortality after Liver and Pancreas Operations, 195.

MOSCHCOWITZ, ALEXIS V.: Treatment of Gastric and Duodenal Ulcer, 548.

Musculo-spiral Nerve, Repair of the, 406.

Myeloma, Multiple, of the Plasma-cell Type, 14.

Myxosarcoma of Thigh Involving the Femoral Vessels, 422.

N

NARAT, JOSEPH K.: Experimental Study upon the Use of Intra-abdominal Injections of Hypertonic Glucose Solution in the Treatment of Peritonitis, 357.

NASSAU, CHARLES F.: Traumatic Lesions of the Head, 94.

Neck, Inoperable Melanotic Sarcoma of the, 414.

Nerve, Repair of the Musculo-spiral, 406.

Nerves, Cervical, Incised Wound of the Fourth and Fifth, 402.

Nervous System, Central, Review of Tilney on the Form and Functions of the, 124.

NEUBAUER, B. B.: Plan of Management of Cranial Injuries, 674; Traumatic Lesions of the Head, 95.

NEUHOF, HAROLD: Myxosarcoma of Thigh Involving the Femoral Vessels, 422; Excision of Adventitia of Brachial Artery (Leriche Operation) for Raynaud's Disease, 428.

Neuritis and Perineuritis of Arm, 89.

NEW YORK SURGICAL SOCIETY: Transactions of the, 104, 414, 544, 549, 677.

Nose, Repair of Loss of Bridge of, 538.

O

O'CONOR, JOHN: Diet after Gastro-enterostomy, 118; Relation of Cirrhosis of Mesentery and Sub-peritoneal Lipomatosis to Alcohol and Work, 751.

Œsophago-cutaneous Fistula, Transpleural, 96.

Œsophagus, Primary Sarcoma of the, 577.
Oden, Rudolph J. E.: Diaphragmatic Hernia, 660.
Orthopædic Surgery, Jones and Lovett, Review of, 128.
Ossification in Kidney Stones, 239.
Osteomyelitis of the Spine, 119.
Owen, Hubley R.: Pleural Epilepsy, 6; Bullet Wound of Thigh Producing Traumatic Aneurism of Femoral Artery, 405; Hernioplasty, 410.

P

Pancreas and Liver Operations, Mortality after, 195.
Pancreatic Asthenia, 177.
Parotiditis, Post-operative Infective, 568.
Patella, Fracture of, after Arthrotomy, 106.
Peck, Charles H.: Treatment of Chronic Gastric and Duodenal Ulcer, 547.
Pemberton, John De J.: Surgery of the Thyroid and its Mortality, 146.
Peptic Ulcer, The Use of the Cautery in, 206.
Perforation, Acute, of Duodenal Ulcer, 342; of the Stomach, 678, with Transposition of Viscera, 679; in Utero of a Gastric Ulcer, 36.
Peri-arterial Decortication, Healed Trophic Ulcer of Amputation Stump following, 428.
Periosteal Sarcoma of Femur, 417; of Fibula, 415.
Perineuritis and Neuritis of Arm, 89.
Peritonitis, The Use of Intra-abdominal Injections of Hypertonic Glucose Solution in the Treatment of, 357; of Undetermined Origin, Acute Intestinal Obstruction Caused by, 116.
Permar, Howard H.: End Results of Arterial Transplants, 305.
Peterson, Edward W.: Intussusception in Infants, 682.
Pfeiffer, Damon B.: Anaphylaxis following Blood Transfusion, 88; Gunshot Fracture of the Femur and Wounds of the Femoral Vessels Requiring Amputation, 405.
Phemister, Dallas B.: Ossification in Kidney Stones, 239.
Philadelphia Academy of Surgery: Transactions of the, 87, 93, 401, 534, 666.
Phillip's Treatise on Diseases of the Ear, Nose and Throat, Review, 686.
Pilcher, James T.: Review of Deaver on Enlargement of the Prostate, 126.
Pilcher, Lewis S.: Review of Biography of Lawson Tait, 122; Review of Amer. Surg. Assn. Report on Treatment of Fractures, 128.
Plastic Operations, Immediate, Involving Tendons and Joints in Injuries, 100.
Plastic Repair of Cheek, 87.
Pleural Cavity, Empyema of the, 711.
Pleural Epilepsy, 6.
Pneumoventricle of the Cerebrum, 561.
Pollicis, Extensor Longus, Rupture of Tendon of, 87.
Prostate, Transpubic Removal of the, for Carcinoma, 795.
Prostatectomy, the Control of Hemorrhage for, 802.
Purpura, Hemorrhagic, Splenectomy in, 186.

R

Randall, Alexander, Torsion of the Testicle, 666.
Raynaud's Disease, Excision of Adventitia of Brachial Artery (Leriche Operation) for, 428.
Rectum, Anus and Colon, Treatise on the Diseases of, by Samuel G. Gant, Review of, 685.
Reid, Mont. L.: Drainage of the Common Bile Duct, 620.
Renal Artery, Aneurism of the, 628.
Renal Calculus, Certain Features of, 231.
Renal and Ureteral Surgery, The Technic of, 641.

Riley, Henry A.: The Form and Functions of the Central Nervous System, 124.

Roberts, John B.: Repair of Nose Defect, 539.

Rodman, J. Stewart: Neuritis and Perineuritis of Arm, 89; Acute Intestinal Obstruction Caused by Meckel's Diverticulum, 92; Traumatic Lesions of the Head, 94; Plan of Management of Cranial Injuries, 674.

Rugh, J. T.: Result of Arthroplasty for Ankylosis of Jaw, 542.

Rusk, G. Y.: Primary Sarcoma of the Œsophagus, 577.

S

Samuels, Saul S.: Acute Deferentitis and Funiculitis, 785.

Santee, Harold E.: Chronic Hypertrophic Villous Arthritis of the Knee, 104; Fracture of Patella after Arthrotomy, 106; Anthrax and its Treatment, 326; Embolus of Axillary Artery, 550.

Sarcoma, Giant Cell, of the Femur, with Metastasis in the Femoral Vein, 846; Inoperable Melanotic, of the Neck, 414; Periosteal, of Femur, 417; Periosteal, of Fibula, 415; Primary, of the Œsophagus, 577; of Testis, 108.

Sarnoff, Jacob: Extensive Resection of the Small Intestine, 745.

Scaphoid, Carpal, Fracture of, 545.

Scaiefe, B. F.: The Meltzer-Lyons Test in the Diagnosis of Gall-bladder Disease, 604; Tarsal, Dislocation of, 544.

Schley, Winfield Scott: Recovery from Gangrenous Intussusception, 683; Lympho-sarcoma of the Tonsils with Cervical Metastases, 112.

Scleroderma with Gangrene of Fingers, 814.

Semilunar, Dislocation of, 545.

Shallow, Thomas A.: Traumatic Lesions of the Head, 26.

Shawan, Harold Koch: Acute Perforation of Duodenal Ulcer, 342.

Sherwood, Walter A.: Relation of Surgery to the Vascular Sympathetic System, 321, 429; Colectomy for Chronic Intestinal Obstruction, 425; Acute Obstructive Duodenal Ulcer, 427.

Size, A Question of, 140.

Skull, Fracture followed by Pneumoventricle of the Cerebrum, 561; Management of Injuries to the, 433.

Smith, Curtis E.: Primary Sarcoma of the Œsophagus, 577.

Smith, Morris K.: Embolus of Axillary Artery, 549; Unreduced Separation of Lower Radial Epiphysis, 550.

Smith, William Randolph: Cardiorraphy in Acute Injuries, 696.

Sodium Chloride, Therapeutic Value of the Administration of, in Intestinal Obstruction, 755.

Speese, John: Spina Bifida Occulta, 534; Subastragaloid Dislocation, 536.

Spina Bifida Occulta, 534.

Spine, Osteomyelitis of the, 119.

Splenectomy for Advanced Splenic Anæmia, 408; for Banti's Disease, 557; in Hemorrhagic Purpura, 186.

Splenomegaly, 553, 669.

Stetten, De Witt: A Modified Inguinal Hernioplasty, 48; Repair of the Musculospiral Nerve, 407; Technic of Inguinal Hernioplasty, 410; The Relation of Surgery to Certain Disturbances of the Vascular Sympathetic System, 429.

Stifel, Richard E.: Osteomyelitis of the Spine, 119.

Stillman, Alfred: Metal Plates in Fractures of the Long Bones, 75.

St. John, Fordyce B.: Ununited Fracture of Femur, 550.

Stomach, Acute Perforation of the, 678; Operative Curability of Carcinoma of the, 332; Penetrating Ulcer of the Lesser Curvature of, 545; Resection of for Chronic Gastric and Duodenal Ulcer, 507.

STONE, HARVEY B.: Combined Abdomino-Thoracic Approach in Operations for Diaphragmatic Hernia, 32.

Stones, Kidney, Ossification in, 239.

Streptococcic Infection, Inoperable Melanotic Sarcoma of the Neck, Entire Disappearance under Accidental, 414.

Subastragaloid Dislocation, 536.

Sympathetic System, Relation of Surgery to the Vascular, 321, 429.

T

TAIT, LAWSON: His Life and Work, by W. J. Stewart McKay, Review of, 122.

TAYLOR, ALFRED S.: Prevention of Recurrence after Operation for Inguinal Hernia, 560.

TAYLOR, WILLIAM J.: Neuritis and Perineuritis of Arm, 90; Acute Intestinal Obstruction Caused by Meckel's Diverticulum, 92.

TEACHENOR, FRANK R.: Pneumoventricle of the Cerebrum following Fracture of the Skull, 561.

Tendon, Conjoined, Hernia Through the, 300; of Extensor Longus Pollicis, Rupture of, 87.

Tendons or Joints, Immediate Plastic Operations in Injuries Involving, 100.

Tendon-transplant for Drop Wrist, 553.

Testicle, Malignant Tumors of the, in Children, 761; Torsion of the, 666.

Testis, End Results in Malignant Disease of the, 370; Sarcoma of, 108.

Thigh, Bullet Wound of, Producing Traumatic Aneurism of Femoral Artery, 403; Myxosarcoma of, Involving the Femoral Vessels, 422.

THOMPSON, JAMES E.: Fracture Dislocation of the Vertebræ, 260.

Thoracopuncture, Intercostal, for the Removal of Penetrating Projectiles in the Lung, 501, 537.

Thyroid Gland, Importance in Surgery of the Correct Differential Diagnosis of Diseases of, 572; Surgery of the, and its Mortality, 146.

TILNEY, FREDERICK: The Form and Functions of the Central Nervous System, 124.

TINKER, MARTIN B.: The Many-stage Operation for Goitre, 151.

Tongue, Abscess of the, 496; Cancer of the, 461, 469, 474; Leucoplakia of, 474; Pathology and Surgical Treatment of Leukokeratosis of, 469.

Tonsils with Cervical Metastases, Lymphosarcoma of the, 112.

TOREK, FRANZ: Recurrence of Inguinal Hernia after Operation, 558.

Torsion of the Testicle, 666.

Transfusion of Blood, Fatal Anaphylaxis following, 1.

Transplants, Arterial, End Results of, 305.

Transpleural Œsophago-cutaneous Fistula, 96.

Traumatic Lesions of the Head, 26.

TRUESDALE, PHILEMON E.: Cancer of the Tongue, 461.

TRUESDELL, EDWARD D.: Shortening following Fractures of the Femur in Children, 421.

TURNER, W. G.: Giant-cell Sarcoma of the Femur with Metastasis in the Femoral Vein, 846.

TUTTLE, HOWARD K.: Acute Intestinal Obstruction Caused by Chronic Organizing Peritonitis of Undetermined Etiology, 116.

U

Ulcer, Acute Obstructive Duodenal, 427; Duodenal, Acute Perforation of, 342; of the Duodenum, 546; and Duodenum and Stomach, Resection for, 507, 546.

Ulcer, Peptic, The Use of the Cautery in, 206; of the Stomach, Penetrating, 545; Healed Trophic, of Amputation Stump following Peri-arterial Decortication, 428.

Ureteral and Renal Surgery, The Technic of, 641.

Ureteral Stump following Incomplete Ureterectomy, Empyema of the, 387.
Ureterectomy, Empyema of the Ureteral Stump following Incomplete, 387.
Utero, Perforation of a Gastric Ulcer in, 36.
Uterus, Bullet Wound of Pregnant, 93.

V

Vale, C. Fremont: Acute Perforation of Duodenal Ulcer, 342.
Vascular Sympathetic System, Relation of Surgery to the, 321, 429.
Vein, Wound of Femoral Artery and, 84.
Vertebræ, Fracture-dislocation of the, 260.
Vessels, Femoral, Requiring Amputations, Gunshot Fracture of the Femur and Wounds of the, 405.
Vesical Calculus, 666, 668.
Vietor, John A.: Fracture of Carpal Scaphoid, 545.

W

Walker, George: Transpubic Removal of the Prostate for Carcinoma, 795.
Watts, Stephen H.: Cardioplasty for Cardiospasm, 165.
Waugh, Theodore R.: Giant-cell Sarcoma of the Femur with Metastasis in the Femoral Vein, 846.
Webbed Fingers, Treatment of, 532, 543.
Wells, J. Ralston: Perforation in Utero of a Gastric Ulcer, 36.
Whitman, Royal: Chronic Hypertrophic Villous Arthritis of the Knee, 106; Periosteal Sarcoma of the Femur, 419.
Whipple, Allen O.: Pancreatic Asthenia, 177; Splenomegaly, 553.
Willard, DeForest: Immediate Plastic Operations in Injuries Involving Tendons or Joints, 100.
Wilensky, Abraham O.: Abscess of the Tongue, 496; Bile Drainage for Hypercholesterolemia, 594; Acute Deferentitis and Funiculitis, 785.
Wood, Alfred C.: Multiple Myeloma, 14.
Woolsey, George: Treatment of Chronic Gastric and Duodenal Ulcer, 546.
Worcester, James N.: Fracture of the Surgical Neck of Humerus, 552; Tendon Transplant for Drop Wrist, 553.
Wounds, Gunshot, and Other Injuries of the Abdomen, The Influence of Hemorrhage on the Mortality of, 364.
Wrist, Dropped, Tendon Transplant for, 553.
Wound, Incised, of the Fourth and Fifth Cervical Nerves, 402.
Wrist, Unreduced Dislocation of Radial Epiphysis, 550.

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This Solution is prepared from a special product consisting of primary and secondary proteoses and peptone. It is free from histamin and other toxic substances.

Peptone Solution (Armour) 1 c. c. ampoules, 12 in a box.

Literature on request

ARMOUR AND COMPANY
CHICAGO

Headquarters for the Endocrines